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**International Infantry & Joint Services  
Small Arms Systems Section Symposium, Exhibition & Firing Demonstration**

**13-16 May 2002**

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# STOCK OPTIONS FOR THE WARFIGHTER



DAVE ARMSTRONG -  
WEAPONS BRANCH  
WEAPONS DEPARTMENT  
ORDNANCE ENGINEERING DIRECTORATE  
NAVAL SURFACE WARFARE CENTER  
CRANE DIVISION



# STOCK OPTIONS FOR THE WARFIGHTER



AK-47 "Carbine" vs. M14 Rifle





# STOCK OPTIONS FOR THE WARFIGHTER





## SOPMOD M4 Accessory Kit






**Carrying Handle/Sight**



**ACOG Reflex**  
0-300m Range



**ACOG 4X Scope**  
0-600m Range



**Visible Laser**  
0-300m Range



**AN/PEQ-2  
IR Pointer/Illuminator**  
0-600m Range



**M4A1 Carbine**  
(5.56 mm NATO)



**Backup Iron Sight**  
0-300m Range



**Rail Interface System (RIS)**



**QD Sound Suppressor**  
30 dB Reduction



**Forward HandGrip**



**Visible Light**  
9 Volt



**Modified M203  
Leaf Sight**



**M203 Grenade Launcher  
with QD Mount**



**Special Operations Peculiar Modification to the M4 Carbine (SOPMOD M4) Accessory Kit**

**Program Objective:** To provide Special Operations Forces the ability to adapt the M4A1 Carbine to increase its operational effectiveness through improved target recognition, acquisition, and hit quality during day and night from Close Quarters to 500 meters.

**Program Sponsors:** United States Special Operations Command

**Program Manager:** Crane Division, Naval Surface Warfare Center

**SOPMOD M4 Website:** <http://arimo-eng.crane.navy.mil/408html/sopmod3.htm>



# STOCK OPTIONS FOR THE WARFIGHTER



Army Stock vs. Standard Colt M4



# STOCK OPTIONS FOR THE WARFIGHTER



Basic Enhanced Stock w/ Component Parts





# STOCK OPTIONS FOR THE WARFIGHTER



Enhanced Stock with Issue Colt Stock



# STOCK OPTIONS FOR THE WARFIGHTER



M14 w/Telescoping Stock







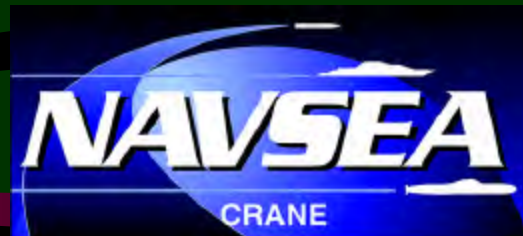
# STOCK OPTIONS FOR THE WARFIGHTER



Maybe not for "every" rifle out there ???????  
Does show adaptability of the M4 stock though



# STOCK OPTIONS FOR THE WARFIGHTER



M1014 Combat Shotgun - In Service w/ USMC





# STOCK OPTIONS FOR THE WARFIGHTER



Side Folding M14, Type 56(AK), Mossberg 500A1



# STOCK OPTIONS FOR THE WARFIGHTER



HK G36A3 Compact, MP5K, Sig 552 Commando -  
All with Side Folding Stocks





# STOCK OPTIONS FOR THE WARFIGHTER



M4A1 Carbine w/ Enhanced Stock & ACOG 4X



# STOCK OPTIONS FOR THE WARFIGHTER



“Iron” Sights



Reflex Sight

HK MP-7 PDW (Personal Defense Weapon)  
Shown with stock retracted and extended -  
Essential for medium range engagements





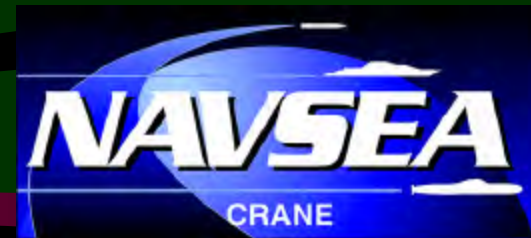
# STOCK OPTIONS FOR THE WARFIGHTER



10" M4 Suppressed w/Enhanced Stock vs. AK-47



# STOCK OPTIONS FOR THE WARFIGHTER



Valmet Model 82



IMI Tavor TAR-21



STKinetics SAR-21



Vector CR-21



# STOCK OPTIONS FOR THE WARFIGHTER



M14 Sniper, M24 Stock, .300 Win Mag Sniper





# STOCK OPTIONS FOR THE WARFIGHTER





## SOPMOD M4 Accessory Kit






**Carrying Handle/Sight**



**ACOG Reflex**  
0-300m Range



**ACOG 4X Scope**  
0-600m Range



**Visible Laser**  
0-300m Range



**AN/PEQ-2  
IR Pointer/Illuminator**  
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**Rail Interface System (RIS)**



**QD Sound Suppressor**  
30 dB Reduction



**Forward  
HandGrip**



**Visible Light**  
9 Volt



**M203 Grenade Launcher  
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**Modified M203  
Leaf Sight**



**Special Operations Peculiar Modification to the M4 Carbine (SOPMOD M4) Accessory Kit**

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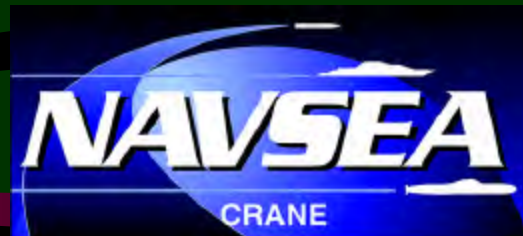
**Program Sponsors:** United States Special Operations Command

**Program Manager:** Crane Division, Naval Surface Warfare Center

**SOPMOD M4 Website:** <http://arimo-eng.crane.navy.mil/408html/sopmod3.htm>



# STOCK OPTIONS FOR THE WARFIGHTER



AN/PVS-17 Mini Night Sight



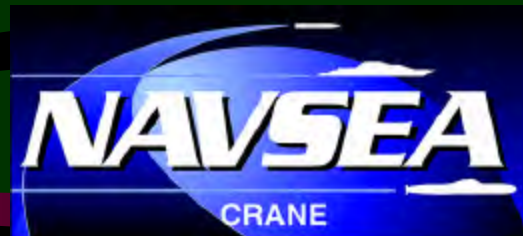
AN/PEQ-2  
Dual IR  
Laser -  
Pointer /  
Illuminator

E - Stock

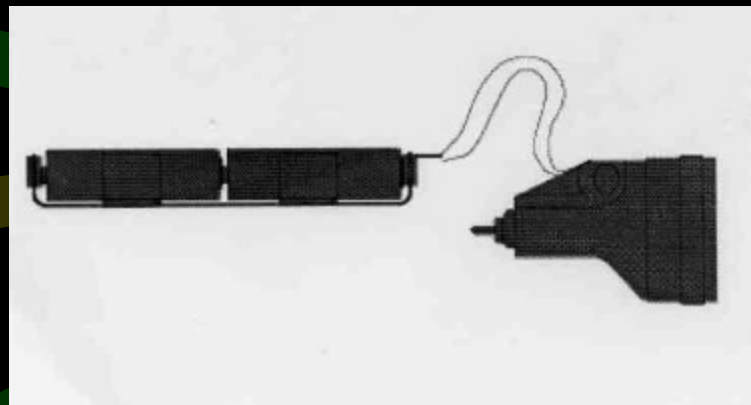




# STOCK OPTIONS FOR THE WARFIGHTER



**SAR-21 with Integral  
Laser in Forestock**



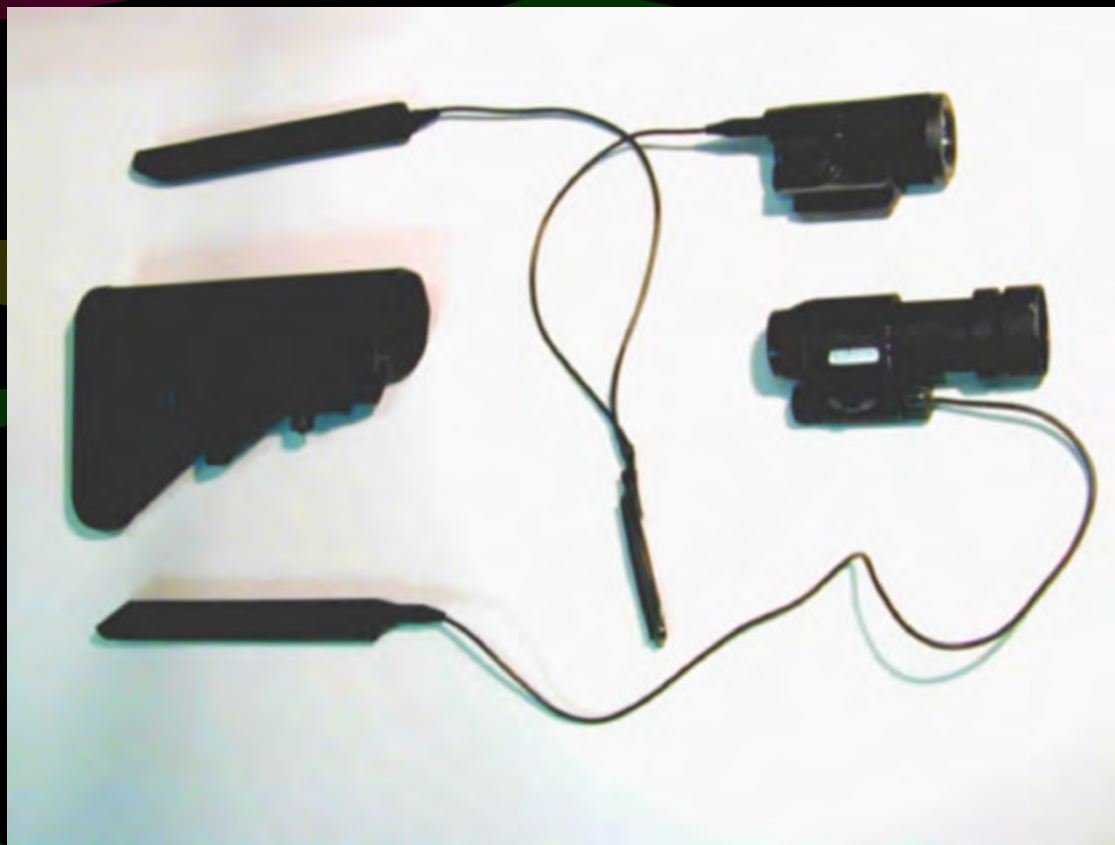
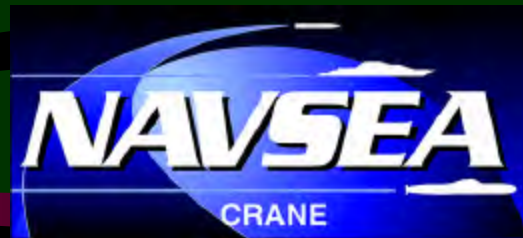
**KEL-TEC SUB 2000 Carbine  
Light Configuration - Battery  
Pack housed in Forestock**



**Polish PM-98 SMG  
Forestock integrates  
Laser or Light replaceable  
with fold-down pistol grip**



# STOCK OPTIONS FOR THE WARFIGHTER

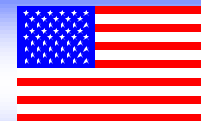


Basic Power Pack Concept w/ Light and AimPoint



# 2002 International Infantry & Small Arms Symposium

"21<sup>st</sup> Century Military Operations and Technology"



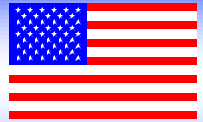
## **Project Manager Soldier Weapons**

**Mr. Richard G. Audette**  
**Deputy PEO Soldier**  
**(Acting)**





# The Threat



**PM Soldier Weapons has responded to the changing threat emphasized by the end of the cold war. The two primary types of warfare with the greatest near term priority are:**

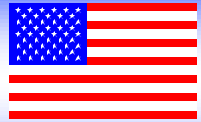
- Remote hostile environments (Afghanistan)
- MOUT

**PM Soldier Weapons has responded to the transformation of the Army through its support of the Objective Force involving the following initiatives:**

- OICW
- OCSW
- OFW
- Legacy Systems



# War on Terrorism



## **Actions taken by PM Soldier Weapons to support the war in Afghanistan:**

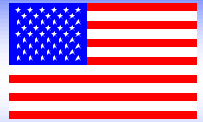
- Three urgent material releases of the XM107 cal .50 Long Range Sniper Rifle
- Out of sequence (accelerated) fieldings of the Modular Weapons System (MWS)
- Supplied six types of non-lethal ammunition included in the urgent material release of non-lethal capability sets
- Provided technical assistance to units getting ready to deploy
- Supported increased M249 SAW replacements due to war related increases in training and preparation for deployment
- Procuring medium machine guns and grenade machine guns for use by other DOD elements

## **Actions taken by PM Soldier Weapons to support Homeland Defense:**

- Procuring rifles, pistols, carbines and medium machine guns for use by Law enforcement and other DOD elements



# Transformation



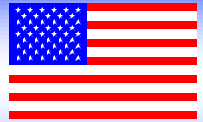
- **OICW – fielded to Land Warrior in FY07. Land Warrior Block III becomes Objective Force Warrior in FY08**
- **OCSW – transitions to PM Soldier Weapons in FY04. Candidate secondary armament for FCS**
- **OFW – working with JSSAP to transition to PM SOLDIER WEAPONS in FY05 Fielded in FY08**
- **Legacy Systems – modernizing/improving to defeat changing threat**







# PM Soldier Weapons



## Questions?

<https://w4.pica.army.mil/opmsa/>  
[gbrown@pica.army.mil](mailto:gbrown@pica.army.mil)  
[raudette@pica.army.mil](mailto:raudette@pica.army.mil)



## **OBJECTIVE CREW SERVED WEAPON**

### **Original OCSW ATD Technology Objective**

Define, Develop And Demonstrate a Lightweight, Two-man Portable, Ground Mounted Crew Served Weapon System with High Explosive Air Bursting Capability Out to 2000 Meters

Mr. Glen Berg  
ATD Manager, OCSW  
DSN 880-6906  
COM: (973) 724-6906  
Email: gberg@pica.army.mil

# OCSW SYSTEM

## Muzzle Device

- Flash Suppression
- Inherently Reliable

## Fuze Setter Contacts

## Fire Control System (FCS)

- Direct View Optics (DVO)
- Range Finder/CIDDS/MILES/Pointing Lasers
- CCD Video/FLIR/Tracker module
- Full Solution Ballistic Calculation/Reticule Aimpoint
- Fuze Programming/Powers and sets Fuze
- Digital Compass/Environmental Sensors

## Weapon

- Light Weight, 27 lbs.
- 25mm, 220 spm
- Soft Recoil
- Gas Operation

## FCS Controls

- Grip mounted switches
- FCS Rear Panel switches
- Lase & Menu select
- Increment/Decrement

## Ammo Can

- Right or left mounted
- Linked Belt
- 31 Round Capacity
- All OCSW Ammo Types

## Ground Mount

- Lightweight, 12 lbs.
- Stable without ballast
- Height adjustable

## Land Warrior Interface

- Lanyard style “breakaway” connector
- Power, data and video over interface
- Compliant to LW requirements



**Camp Pendleton Firing  
Video Clip**

# Revolution in Small Arms Performance

OCSW

Equiv.

Performance

Weight

**Future Capability**

**Revolutionary!**

Max Effective Range (25 mm):

- Defilade Target to 1,000 m
- Area Targets to 2,000 (8 men 10 m x 50 m)
- Airburst, Point Detonation (PD) & Self Destruct Capabilities
- Defeats Targets in Defilade
- Armor Piercing Round 2" HHA/RHA



OCSW - 64 lbs



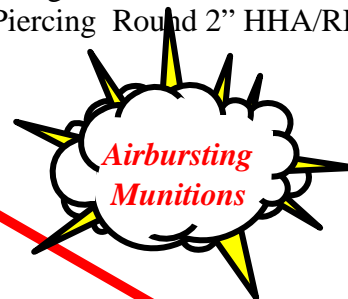
M240 MG - 64.8 lbs



7.62mm KE  
Ball & Tracer

31 X

98%



OCSW Airburst



M2 50 cal. HMG - 171 lbs



.50 cal KE  
Ball, Tracer & SLAP

50X

37%



Mk19 Grenade MG - 208.5 lbs



40mm HE (M433)

Weight = Weapon & Ammo

13 X

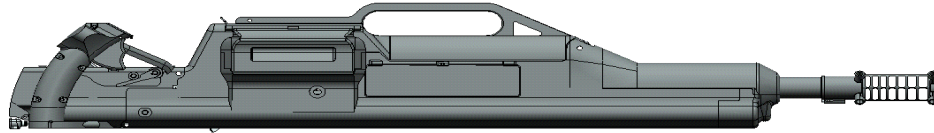
30%

**Evolutionary**

**Current Capability**

# Weapon Initiatives

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- **Simplified receiver casting** - Production Investment Cast aluminum construction
- **Parts Reduction** - 283 parts versus 500 (Mk19) and 397 (M2)
- **Reliability Testing** - Rounds Fired to Date: 10,266
- **Impulse Averaging Soft Recoil System** –  
Barrel Returns to Same Location After Every Shot  
Mass not Required to Stabilize Gun
- **Ammunition Velocity Correction System** –  
Compensates for Round-to-Round Velocity Variation  
Increases Airbursting Accuracy



# OCSW Fire Control

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- Full Solution Fire Control
  - 2.2 km range performance
  - $\pm 1$  meter laser rangefinder
  - Ballistic processor
  - Single reticle
  - Fuze setter
  - Digital compass
  - Embedded training
  - MILES/CIDDS
  - Thermal Interface
  - Direct view optics 5x9.5° FOV
  - Land Warrior ready
  - Full FOV laser steering
  - Motion tracker

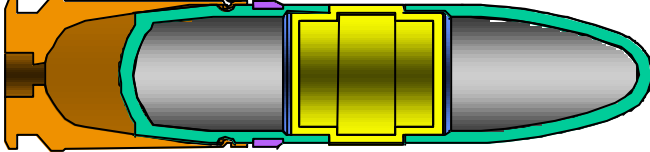


# OCSW BALLISTIC MATCHED 25mm AMMUNITION FAMILY

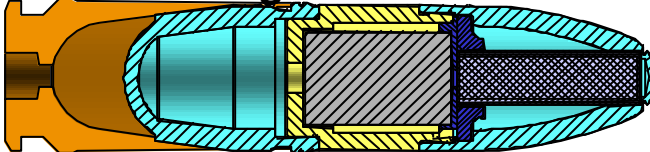
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- Aluminum Cartridge Case
- Standard Ball Propellant
- Standard Percussion Primer

**HE Cartridge**

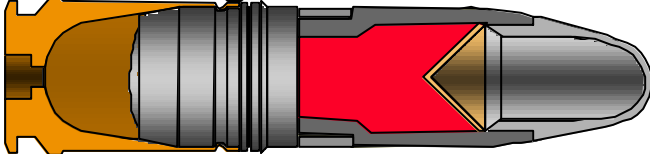


**TP-S Cartridge**

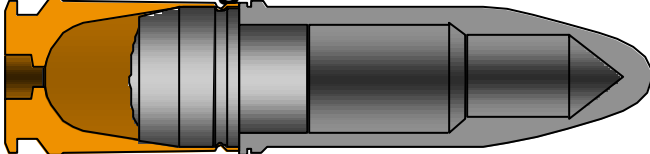


Mini Electronic Time  
Fuze w/ Point  
Detonating/Self  
Destruct Capability

**AP Cartridge**



**TP Cartridge**



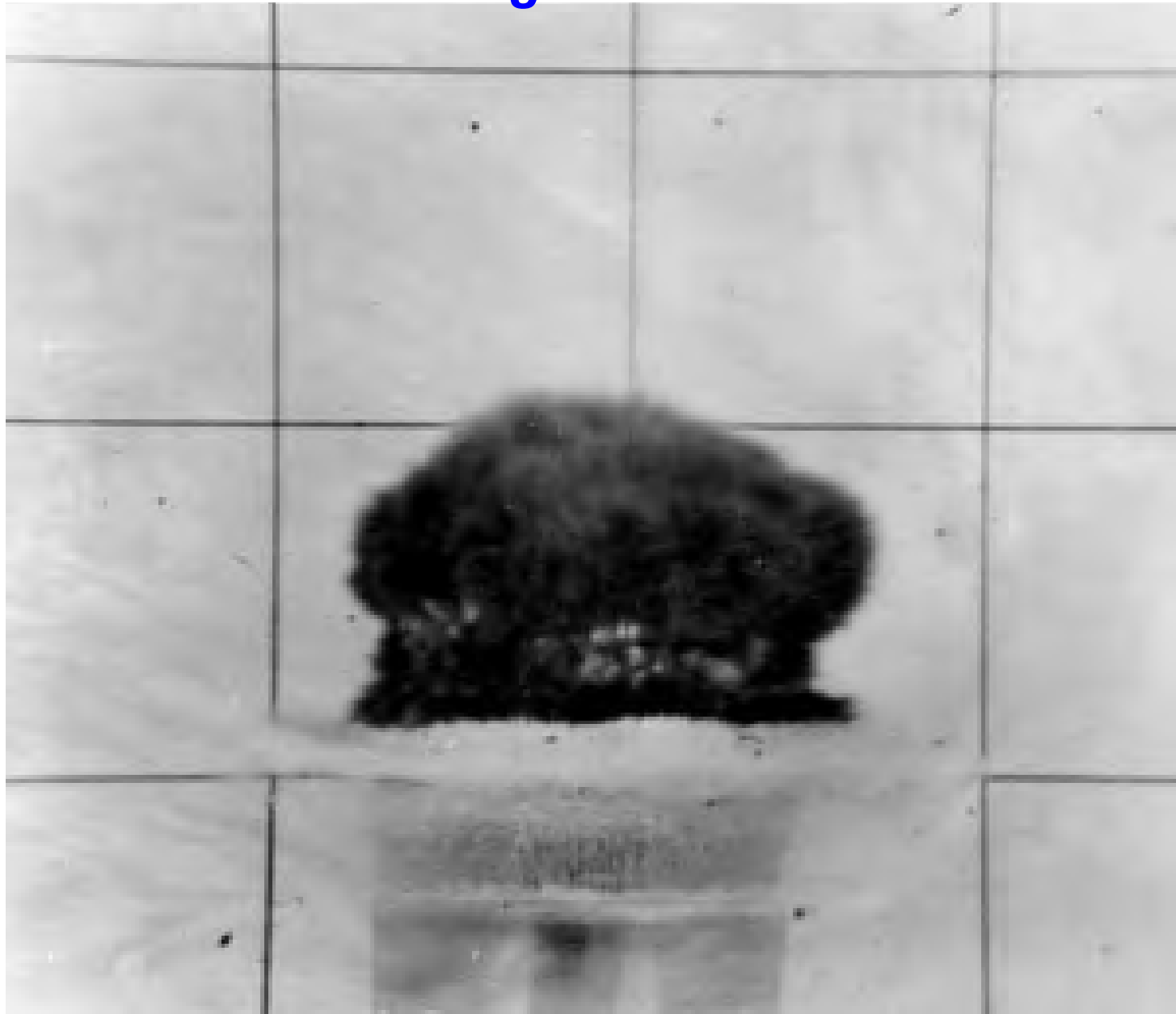
- Precision Air-Bursting @ 2K
- LX-14 High Explosive
- Defeats PASGT Vest & Helmet
- Controlled Fragmentation Warhead

- Flash Bang Training

- 51mm RHA (Threshold)
- 51mm HHA (Goal)

- Two-Piece Projectile
- Integral Rotating Band

## ***Controlled Fragmentation Warhead***

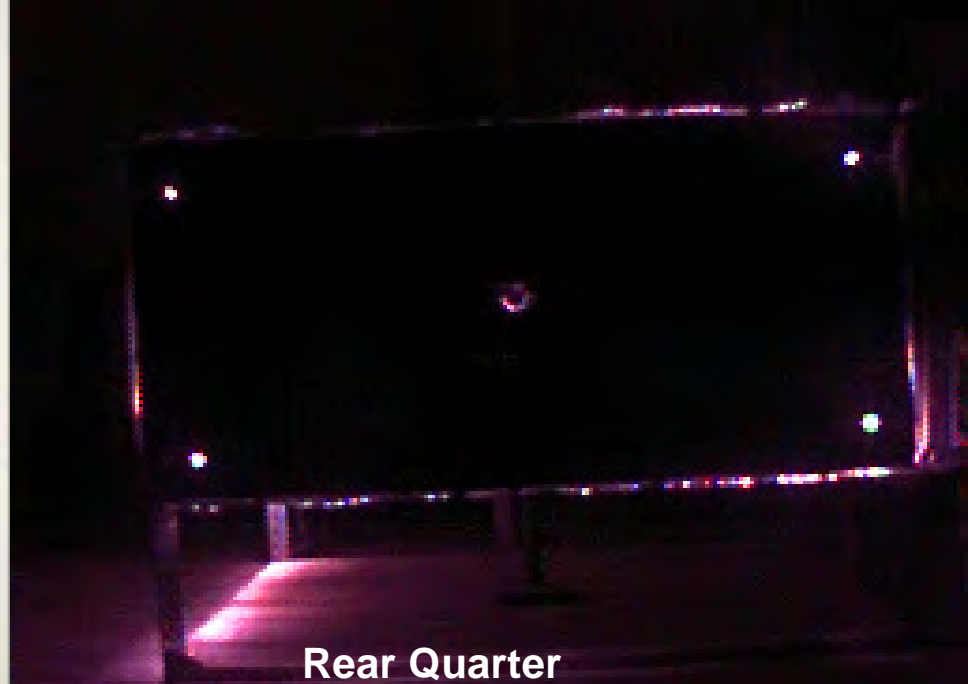


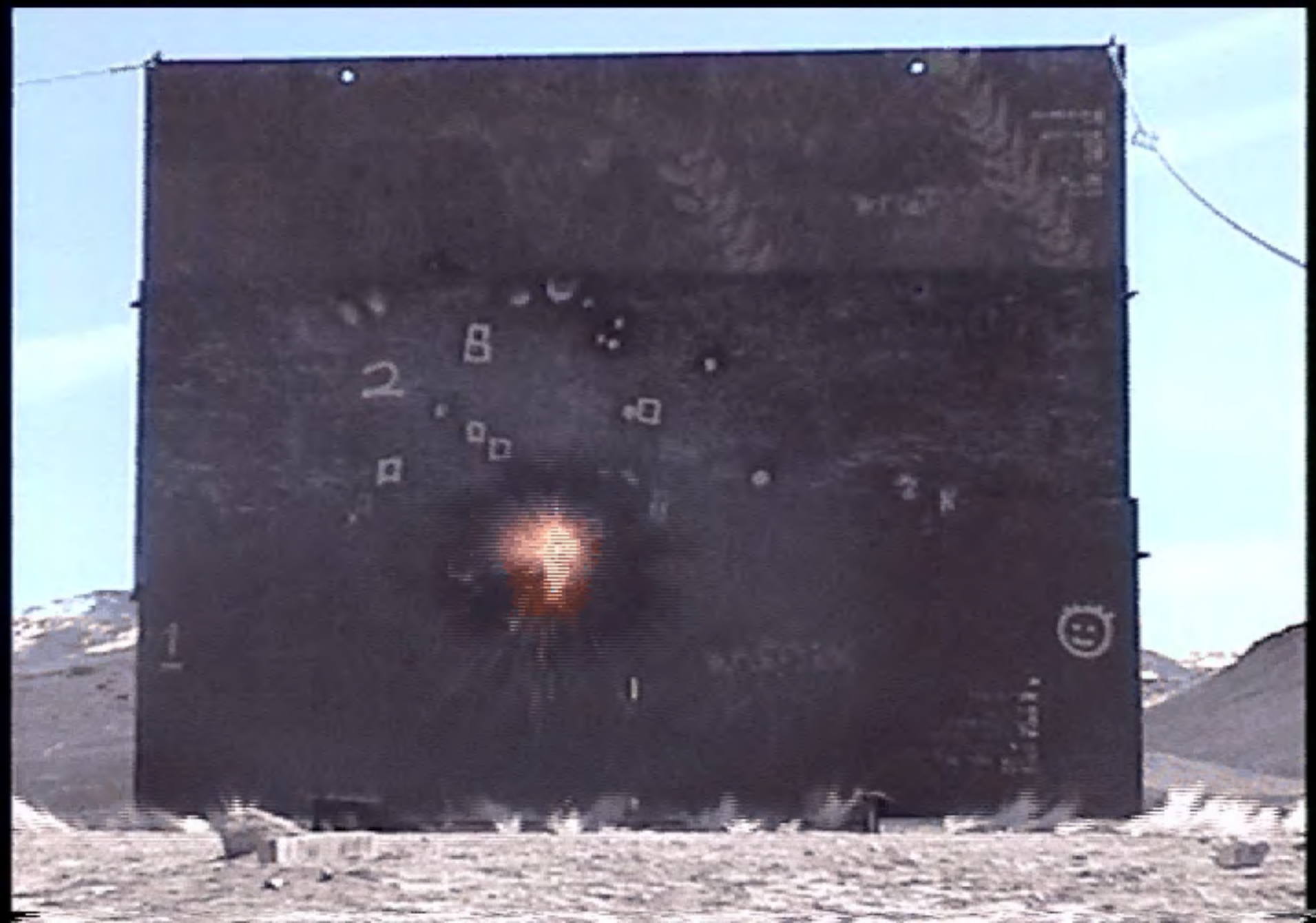
# Fragmentation Tests

Celotex Packs

Warhead

Velocity Screens





Committed To Excellence



## ***ATD Status - Accomplishments***

---

- **Fired remotely at 5 successful System Integration Tests**
- **Demonstrated TA/FCS target ranging and ballistic solution calculation**
- **Demonstrated ability to feed Ballistic solution to ammo-fuze at 250 rounds per minute**
- **Demonstrated velocity correction capability**
- **Demonstrated ammunition airburst accuracy ( <4 meters at 600 meters )**
- **Demonstrated weapon reliability growth ( 100 MRBS )**
- **Demonstrated armor piercing capability**

# *First Manned Firing*

## *26 April 2002*

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## *OCSW As Remotely Operated Secondary Armament*

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### **Programs Expressing Interest in Remote Operation:**

- ✓ Future Combat Systems
- ✓ Future Tactical Truck Systems
- ✓ Active Protection System
- ✓ Multi-Role Ammunition Armament System
- ✓ Crusader
- ✓ Abrams
- ✓ US Coast Guard Deepwater Program
- ✓ Unmanned Combat Armed Rotorcraft

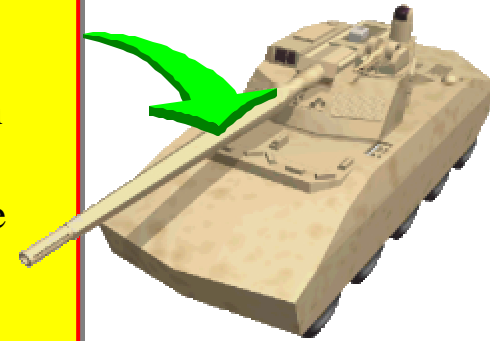
# OCSW As Remotely Operated Secondary Armament

## Integration Tasks for Remote Operation:

- ✓ Add Solenoid For Remote Firing
- ✓ Route Cable And Integrate Weapon Controls With Operator's Station
- ✓ Provide Fire Control Display And Controls At The Operator's Station
- Identify & Select Stabilized Mount
- Install Large Capacity Ammo Container On Mount
- Add Actuators And Resolvers For Laying OCSW Independent Of Main Gun



*Potential Armament  
in Common Remote  
Operated Weapon  
Station (CROWS)*



*Candidate Secondary  
Armament for Future  
Infantry Vehicles*



*Track Vehicle Application*



*Potential Application as Defensive  
Armament for Crusader SPH and RSV*



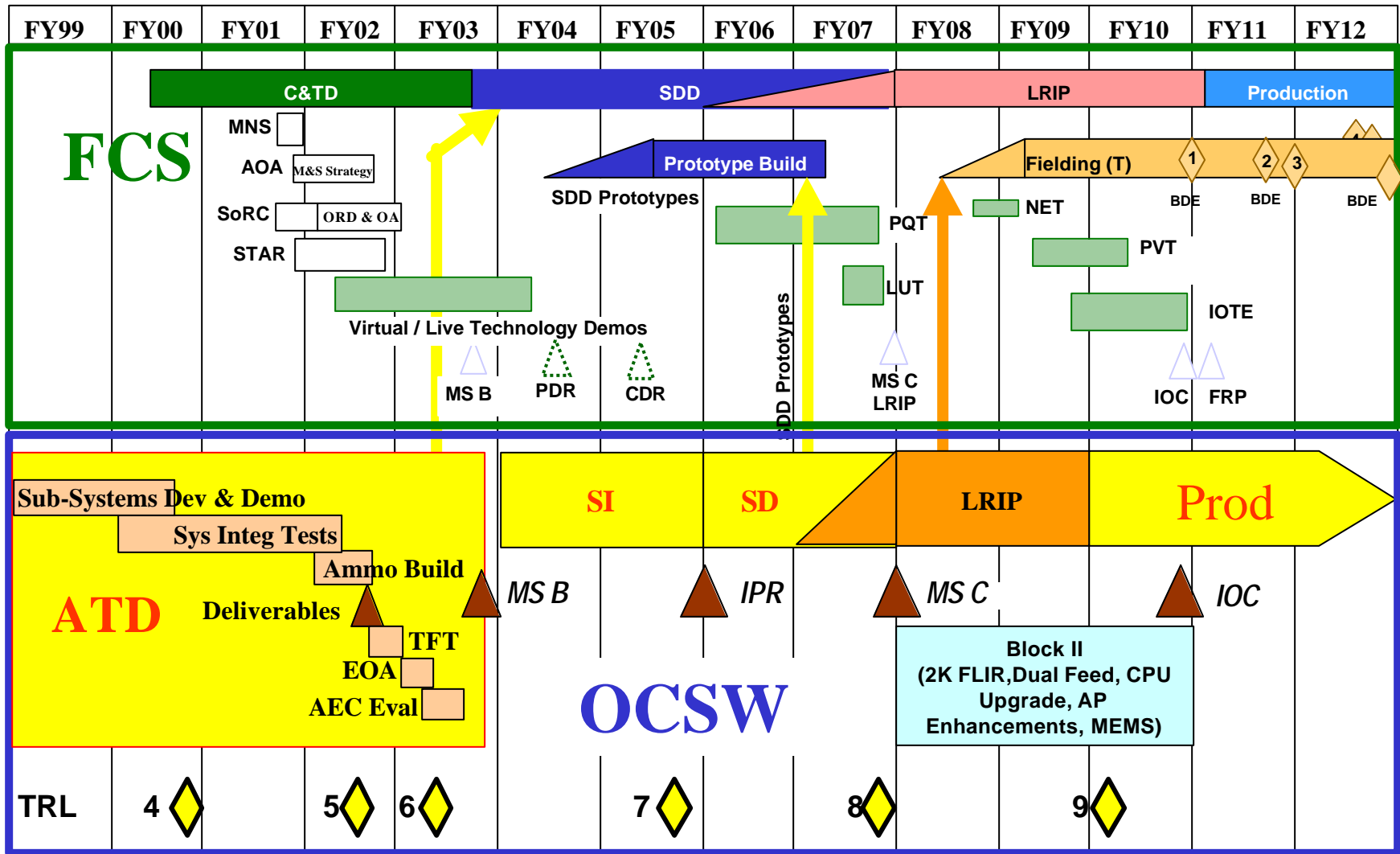
## ***Objective Crew Served Weapon System LSI Discussion***

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- OCSW on All Vehicles  
Except Commander Vehicle  
and Recon Vehicle (Med Cal  
Cannon) in Proposed  
Baseline
- OCSW MS B to be a part of  
FCS MS B (Align MS B on  
Charts)
- OCSW Should Continue  
ORD and AoR, AoA included  
in FCS AoA



# Tie-in with FCS Schedule



# **OBJECTIVE CREW SERVED WEAPON SUMMARY**

---

- ATD Technologies On-Track to Meet Exit Criteria
- PM On-Board for Transition Planning
- Work On-Going to Close Gap Between ORD and Exit Criteria
- OCSW is Prime for Vehicle Applications



# ***2002 International Infantry & Joint Services Small Arms Systems Section Symposium, Exhibition & Firing Demonstration***

***« 21<sup>st</sup> Century Military Operations and Technology »***

***May 13-16, 2002***

**BRIAN BERGER  
CHAIRMAN  
SMALL ARMS SECTION**





# ***2002 NDIA INT'L INFANTRY & SMALL ARMS SYSTEMS SYMPOSIUM***

## **➤ Administrative Announcements**

- Live Fire Demonstration – Ft. Dix N.J.
- NJ National Guard
- Sal Fanelli
- John Resch
- Ft. Dix Personnel

## **➤ Int'l Infantry / Small Arms Committees**



# **2002 NDIA INT'L INFANTRY & SMALL ARMS SYSTEMS SYMPOSIUM**

## **➤ Agenda**

- 80 + papers submitted
- 67 papers selected
- Special thanks to:  
Jim Lamb, Frank Puzychi, Dennis Conway, Joel Goldman, Steve Faintich

## **➤ Exhibitors**

- Floor Space Sold Out
- Visit Exhibitor Booths

## **➤ Conference Evaluations**

- Complete Evaluations
- Return to NDIA





# ***2002 International Infantry & Small Arms Symposium***

## ***21<sup>st</sup> Century Military Operations and Technology***

### ***Objective Force Warrior***

***15 May 2002***

***Philip Brandler  
Director,  
Natick Soldier Center***





# ***Soldier System Paradigm Shift***



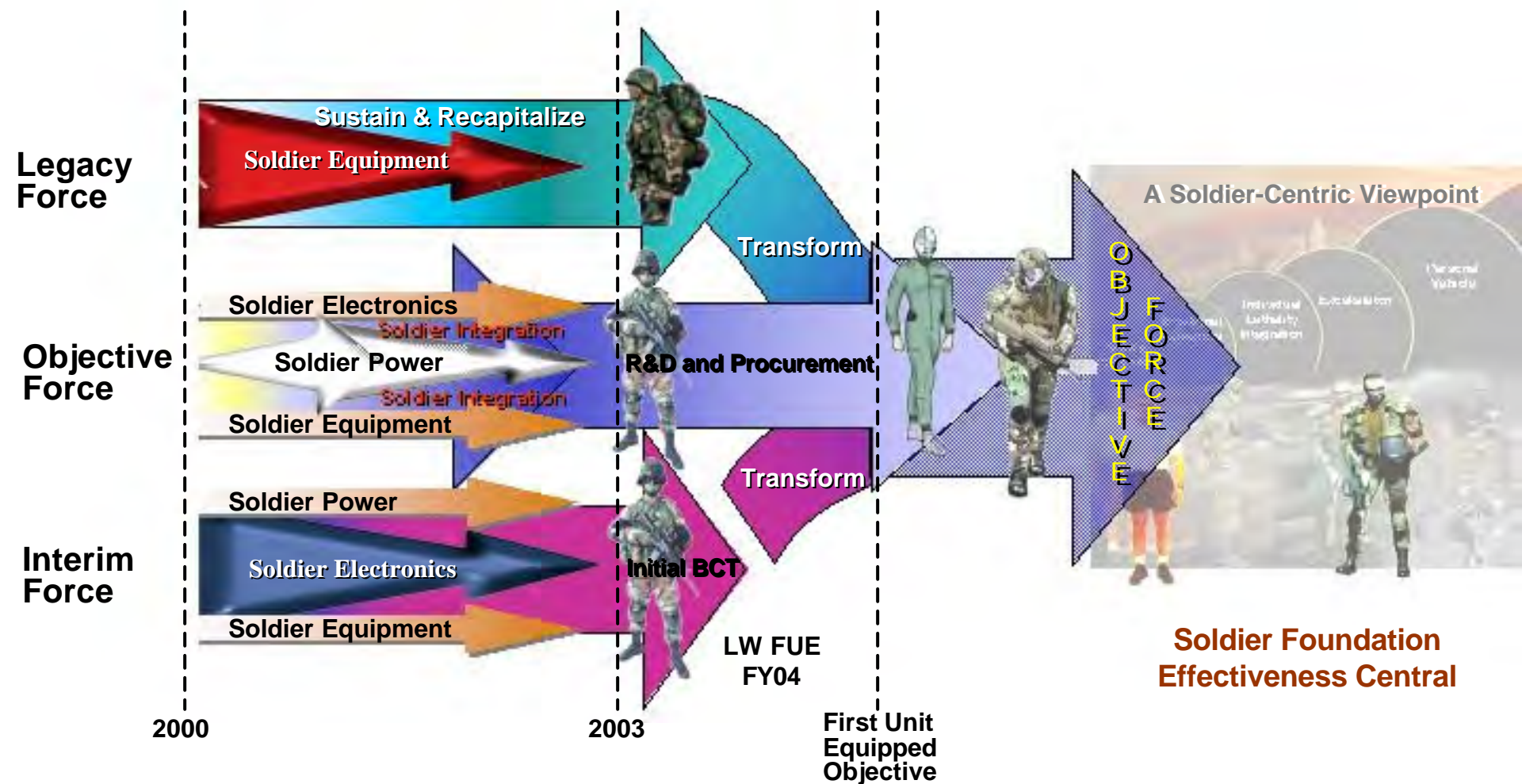
***...Christmas Tree*** 🌲

***...Integrated Human-Centric System***





# Soldier Systems in the Army Transformation



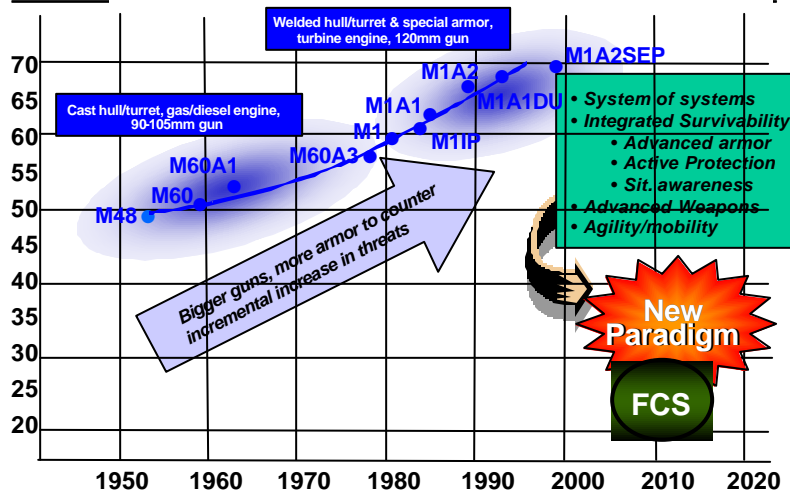
**Soldier Systems are Centric to Army Transformation**



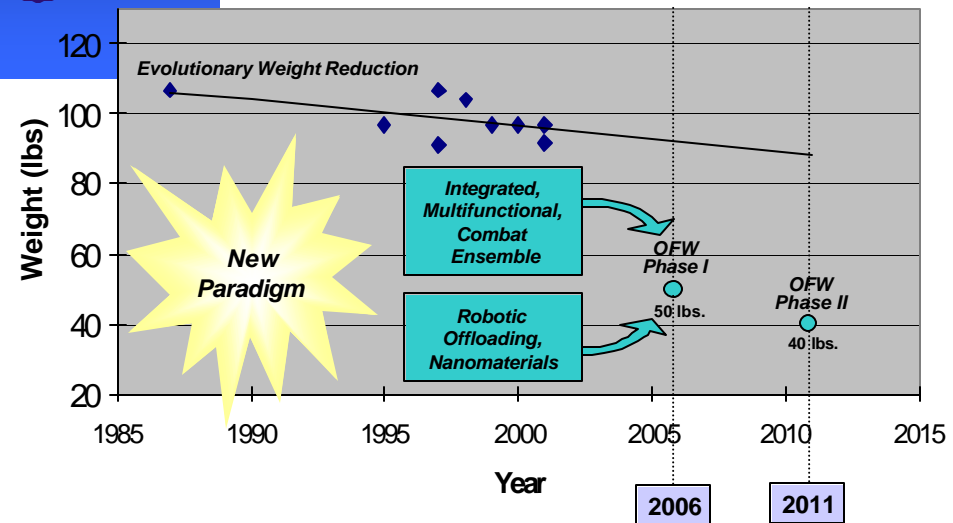
# FCS Thinking Extends to Soldier Systems

**Unprecedented agility and empowerment of soldiers in FCS and OF concepts drives need for a Paradigm Shift**

## Rapid Deployability Drives Need for Paradigm Shift



## Soldier System Weight





# Five Independent Study Panels on Objective Force Warrior



OFW Independent Review Team  
OFW Special Study Group (SSG)  
Army Science Board (ASB) Summer Study on OFW  
Oak Ridge Visioning Teams  
FCS Technology Assessment Panels

Including  
TRADOC  
TSM-Soldier

THE  
RESULTS

**250+ Leading  
Experts from Ind,  
Gov & Acad**

## Consistent Vision & Message

- ✓ Major Technology Investment Needed
- ✓ Revolutionary Improvements over LW Possible
- ✓ Initiate Flagship Objective Force Warrior System of Systems Integration Program
  - Milestone B No Earlier than end of FY06 (as late as FY08) for Leap Ahead

Conducted Between Oct 2000 and Nov 2001



# *IRT View of S&T Investment in the Warrior System*



***Current Warrior S&T Investment is approximately 5% of the Army S&T Budget...***

- **Sufficient to meet the needs of the “Soldier-Centric” Objective Force?**
- **Comparison: FCS investment is 35% of the Army’s S&T**
- **Similar challenges face future warrior systems...**
  - **Increased protection at a lighter weight**
  - **Greater lethality at a reduced weight**
  - **More enduring power sources**





# IRT Findings & Recommendations

## Findings:

- The S&T program can yield revolutionary soldier performance in this decade *if the program is redefined/re-resourced (\$300-400 M over the POM)*

## Recommendations:

- To achieve a revolutionary capability in this decade:
  - Initiate a *flagship* Objective Force Warrior program **NOW**
  - Develop revolutionary warrior system design by following FCS Program strategy

***Revolutionary Soldier Performance Requires Aggressive, High Risk Actions***



# **Land Warrior – A Success Story**

- **It works**
- **Dramatic cost reductions**
- **Big gains in effectiveness**
- **The LW Team deserves high praise**
- **However, significant challenges remain:**
  - **Fightability**
  - **Weight**
  - **Power**
  - **Affordability**
  - **Systems Approach**



# Toward Achieving the Goals

## Factors

C4ISR

Mobility

Lethality

Survivability

Sustainment

People

Affordability

See First

Understand  
First

Act First

Finish  
Decisively

Endure

People

Buy &  
Sustain

## Potential Technical Opportunities

Micro & Mini UAVs & UGVs

Mine/Booby Trap Sensing

Through Wall Sensing

Sniper Detection

Soldier C4ISR Connectivity

Decision Aids

ID Friend, Foe, & Neutral (IFFN)

Responsive Organic & Joint Netted  
Fires

Exoskeleton Assist Systems

Robotic Mule

Sustainment by UAV

Signature Management

Robotic Targeting & Attack

Agile Target Effects

Physiological Monitoring

Power Management

Lightweight Integrated Soldier System

Water Purification & Generation

Acquisition

Assignment

Sustainment

Soldier Life-Cycle

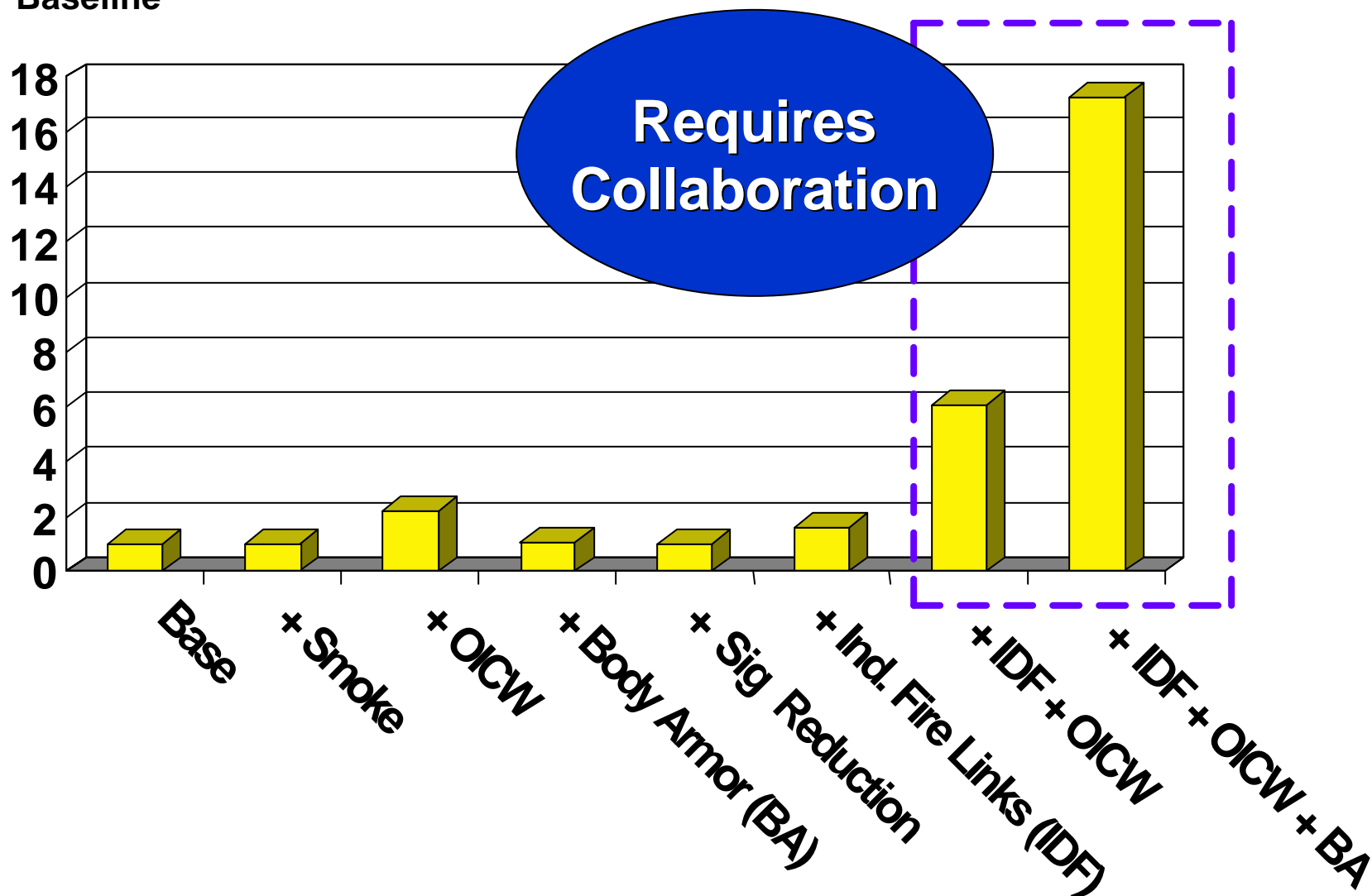
**A Systems  
Approach  
to These Factors  
Is the  
Key to Success**

**10X Effectiveness**



# Alternative Options Show Significant Improvement

LER  
Improvement  
Over  
Baseline



SUMMER STUDY

2001





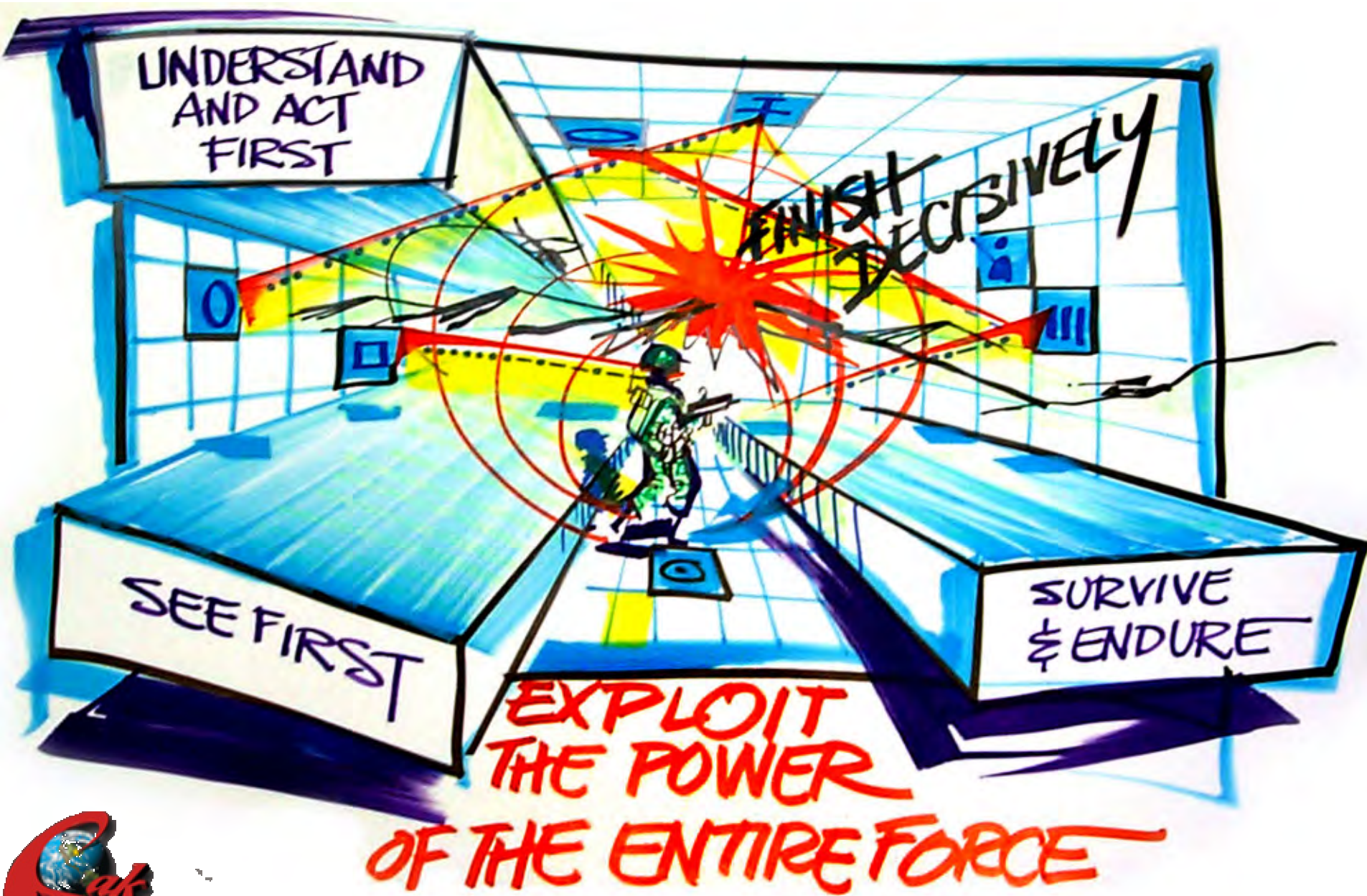
# **Mid Term Recommendations**

## **Objective Force Warrior**

**(TRL7 by 2008 – FUE by 2012)**



**Collaborative**





# ***VISION — Essential Principles***

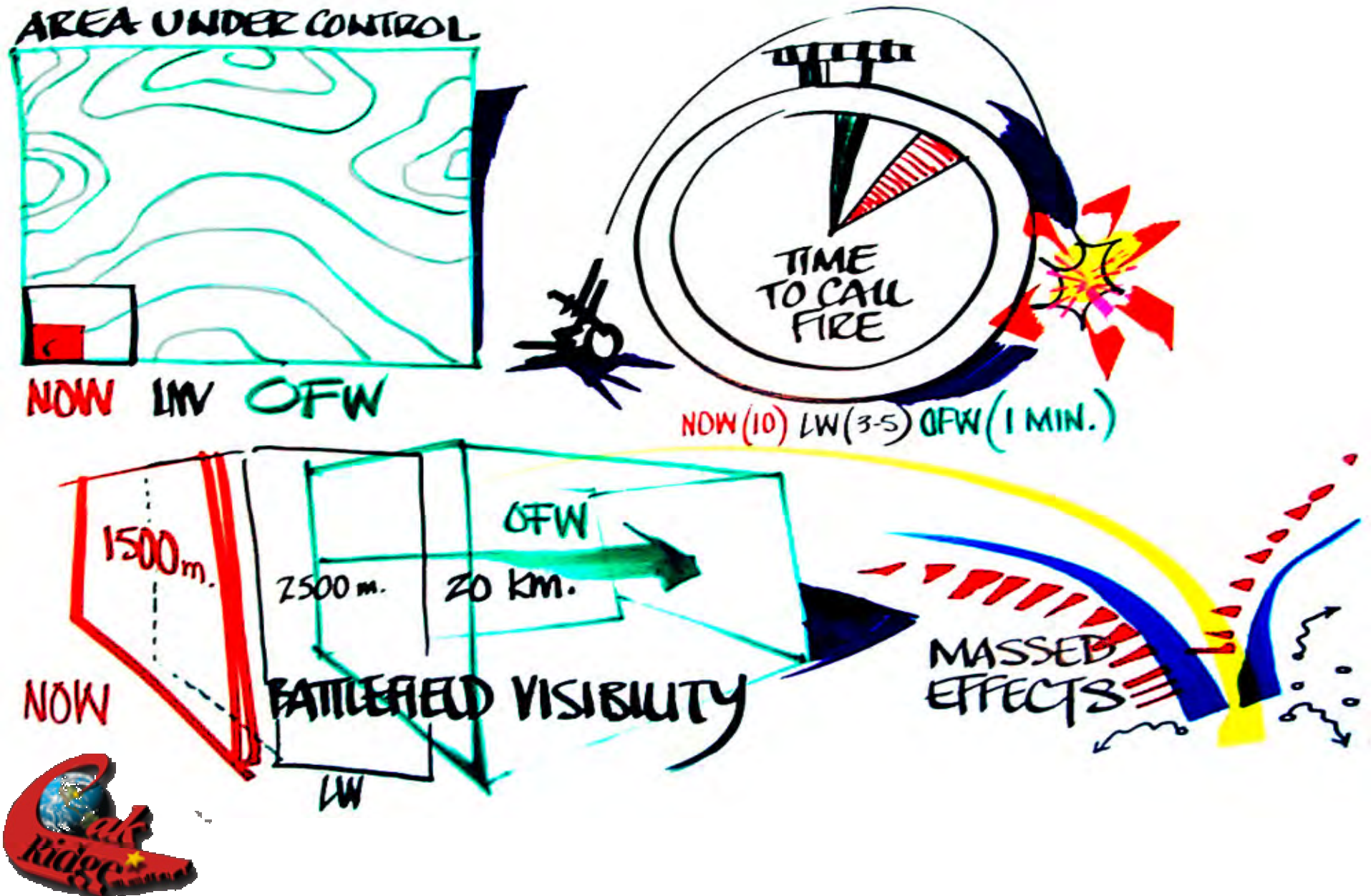


- **“Overmatch” for the Soldier**
  - Dominate with Information
- **Apply the Power of the Force**
  - Collaborative massed effects
- **Three-dimensional Aspect of Effects**
  - Vertical integration
  - Stand-off
  - Expanded Area Under Control
- **Warrior Culture**
  - Human performance - centric design
  - Extended cohesion
  - Paradigm shifts in recruiting, manning, and training
- **Open Architecture**
  - Integrate emerging capabilities continuously





# BATTLEFIELD CONTROL





$\neq W$ 

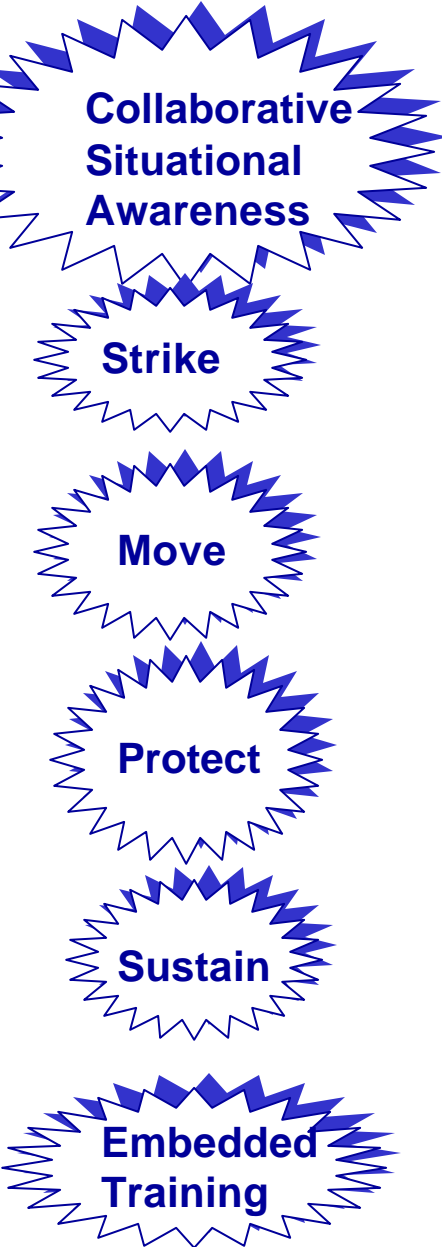
**TODAY**



THE SOLDIER WILL BE  
ABLE TO DO TOMORROW



# ***“MUST HAVE” OFW COMPONENTS***



**Collaborative  
Situational  
Awareness**

**Strike**

**Move**

**Protect**

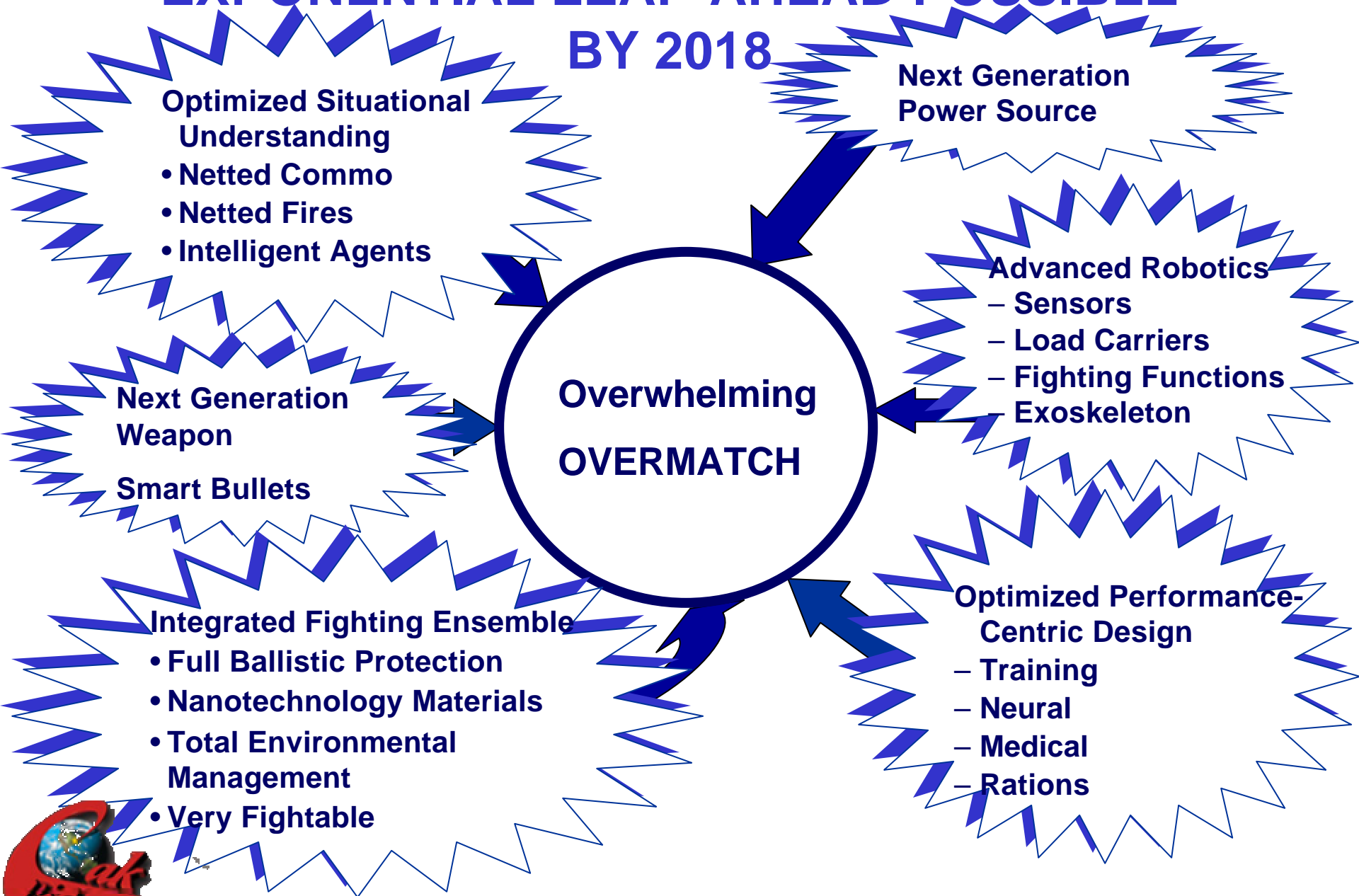
**Sustain**

**Embedded  
Training**

- **Collaborative Situational Understanding**
  - **Netted Communications**
- **Apply/Mass FCS Combat Multipliers to Overmatch**
  - **OCSW critical**
- **Reduce Weight**
  - **UGV load-carrier now**
  - **Lighter equipment technologies**
- **Individual Survivability**
  - **Protective equipment**
  - **Integrated combat ensemble**
- **Power**
  - **Advanced fuel cell**
- **Training Integration**



# EXPONENTIAL LEAP-AHEAD POSSIBLE BY 2018



**More Options to “Close With” and “Destroy”**



# ***EQUIPMENT DEVELOPMENT THOUGHTS***



- **Keep It Small and Simple**
- **Spiral Development (Deploy with Tech Teams for first units)**
- **Field by Unit Sets**
- **Economically Producing in Quantity**
- **Open Architecture to Maximize off the Shelf (Moore's Law)**
- **Modular Mission Payloads (Soldier and Vehicle)**
- **Minimize Logistics Tail**
- **OFW Lead System Integrator Linked to FCS Integrator**







# ***SUMMARY***

**The Old Wisdom Endures — Move, Shoot, Communicate, Along with Survive and Endure, Still Wins**

**The Future Champion — Netted Communications Leading to Situational Awareness, Collaboration, Massed Effects, Sensing, and Synergy is the Key to the Future**

**The Over-Arching Gestalt — Exploit the Power of the Entire Force**

**Four Technology Imperatives — Information, Power, Miniaturization, and Robotics**

**The Urgent Cry — Passionate Call for a “MULE” like Tool**

**The “OTHER FORCE” — The Human-centric Battlefield Dynamics of the WARRIOR CULTURE are Key Combat Multipliers**





# OFW



## *Special Study Group (SSG)*

- **SSG Direction:** Established ('01) by ASA(ALT) to address IRT recommendations
  - Define a vision, investment, and acquisition strategy for Warrior Systems for the Objective Force
- **SSG Composition:**
  - Co-Chaired by Dir, NSC and TSM Soldier
  - Composed of members of the Soldier related technology community, including NSC, ARDEC, CERDEC, MRMC, TARDEC, ARL, ARI, STRICOM
  - Included TRADOC and Users



# ***OFW SSG Process***

## ***Premised on Warfighter Needs***

- **Derived warfighter needs for OFW from key Transformation documentation**
- **Brainstorm capabilities for each need**
  - **Users and developers**
  - **Warfighter SME panel banded capabilities**
- **Broad-based technology inquiry to ID technologies for capabilities to meet needs**
- **OFW Needs not yet Vetted or Prioritized by Headquarters TRADOC**



# OFW Needs Grouped into Capability Areas



**Lethality** - Direct and indirect engagement; less than lethal engagement; target detection/recognition; synchronization of fires; target handoff; ID friendly/enemy/non-combatants; target designation

**C4I** - Situational Understanding; information management; comms; enhanced vision/senses; detect/avoid hazardous areas; area denial; mark items of interest; intel collection & dissemination; mission planning/rehearsal

**Power Sources** - High Density, lightweight, efficient, safe, reliable power (hybrids, rechargeable)

**Analysis & Assessment** - Modeling tools to enable optimal system development and assessment; virtual prototyping; individual and force on force modeling



**Survivability** - Full spectrum individual protection; signature management; thermal management; physiological status monitoring

**Mobility** - Horizontal, vertical mobility; reduce/offload equipment carriage; ID/reduce/defeat obstacles; position/location/tracking

**Sustainability** - Delivery of tactical resupply; water purification/generation; water management

**Training** - Individual, small unit, leader training concepts; embedded training, novel TTPs to exploit OFW capabilities

**Human Performance** - Sustain and enhance Individual and team performance; optimize system and team fightability; optimize human endurance, cognitive and physical capabilities

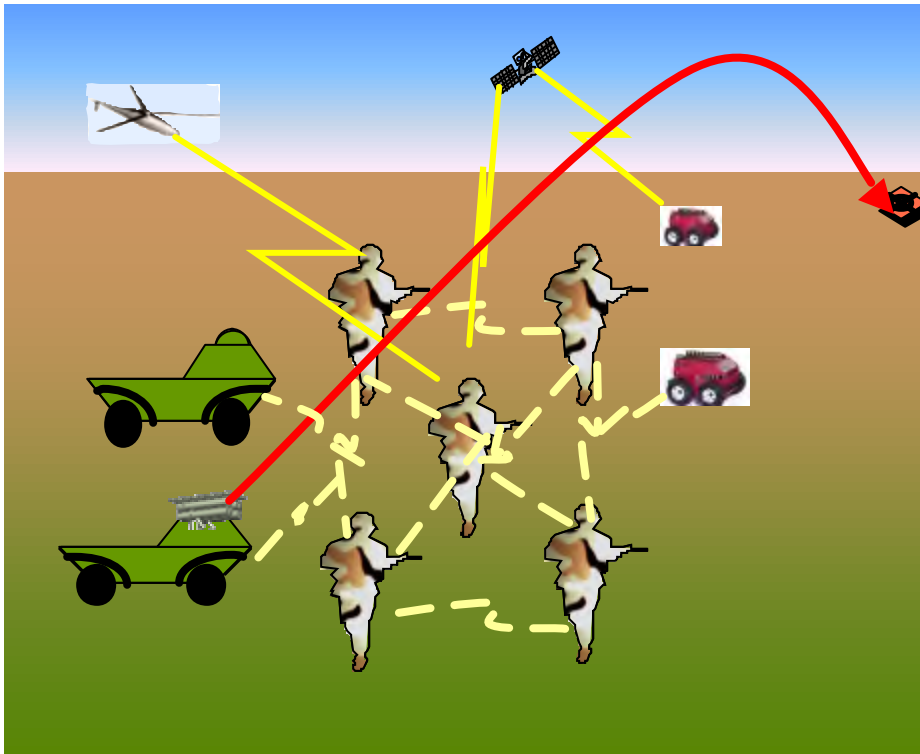
**System Engineering and Integration** - Integrate all technical areas into comprehensive, integrated system of systems; weight, power, and cost treated as independent variables

## OFW Capabilities Create A Formidable Warrior.....





# *....In an Invincible Team*



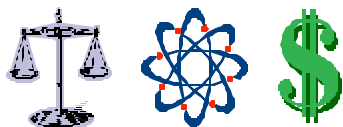
- A combined arms force at the fire team level
- C4ISR Provides leap-ahead overmatch effectiveness
  - Collaborative real time planning and execution
  - Coordinated LOS and BLOS fires and movement
- Robotic “Mules,” “Dogs” and “Eagles” provide
  - Remote sensing
  - Mobility
  - Sustainment
  - Lethality

***Many Revolutionary Capabilities Are Within Our Reach***



# Technology & Systems Integration

## Systematic Incorporation of Revolutionary Technologies



***Balance  
Weight,  
Power, Cost &  
Performance***

***Human  
Performance  
& Integration***

- **Integrated Process Product Development & Integrated Product Teams**
  - *Maximizes Developer, Producer, User Interaction & Produces the “Best” System*
- **Holistic System Design Approach**
  - *Maximize Human / System Performance*
- **Robust Analysis & Assessment**
  - *Leverage Government Modeling & Analysis Tools*
- **Synchronize with Objective Force Systems (e.g., FCS, C<sup>3</sup> on the move, Networked Sensors)**

**Program Structured to Leverage both DoD & Marketplace Technology**



# ***Finding the Balance***



**How  
Integrated  
Can It Be?**

**How  
Modular  
Does It  
Have To Be?**

**Weight and Bulk**

**Mission Flexibility  
Technology Upgrades**



# ***Combat Ensemble -***

## ***The Chassis for Technology Integration***



**Physical  
Interfaces &  
Integration**

**Human  
Interfaces &  
Integration**

***Interfaces & Integration  
Both Within and  
External to Chassis***



**Electronic  
Interfaces &  
Integration**

**Software  
Interfaces &  
Integration**

***Human Centric  
System Architecture***





# ***The Objective Force Warrior Program***



***A Revolutionary Capability For The Objective Force***



- **Scope: All Combat Warriors within Objective Force Unit of Action**
- **Diverse, Large Scale Integration Program Structured to Leverage cutting edge Technologies from both Government & Industry**
  - **Currently in S&T Phase**
- **System of Systems Concept Tailored to Maximize Effectiveness of Team of Teams Operations**
- **Synchronized/Compatible with FCS**



# *Planned Technologies for Objective Force Warrior*



- **Near Real Time Fire Synchronization**
  - Netted FCS Fires
  - OFW Direct & Area (w/ HE from OICW, OCSW)
- **Ultra-Light Grenade Launcher, Kinetic Energy (KE) Combat Rifle, Machine Gun & Ammo (Block II)**
  - Integrated Multi-Spectral Fire Control
- **Hybrid Fuel Cell Energy Systems**
  - Reduced Logistics Footprint & Cost
- **Compact, Low Power Networking Digital Radio (SUO/SAS ?)**
  - JTRS Compatible
  - Voice, Data & Video
- **OFW Mobile, Ad Hoc Tactical Network**
  - Links Warriors, Mules, & Team UAV
  - WIN-T Compatible for FCS Network Integration
  - Dominant Information & Awareness
- **Hybrid All Terrain Navigation**
  - 3 Meter, Vertical & Horizontal Accuracy



# *Planned Technologies for Objective Force Warrior*

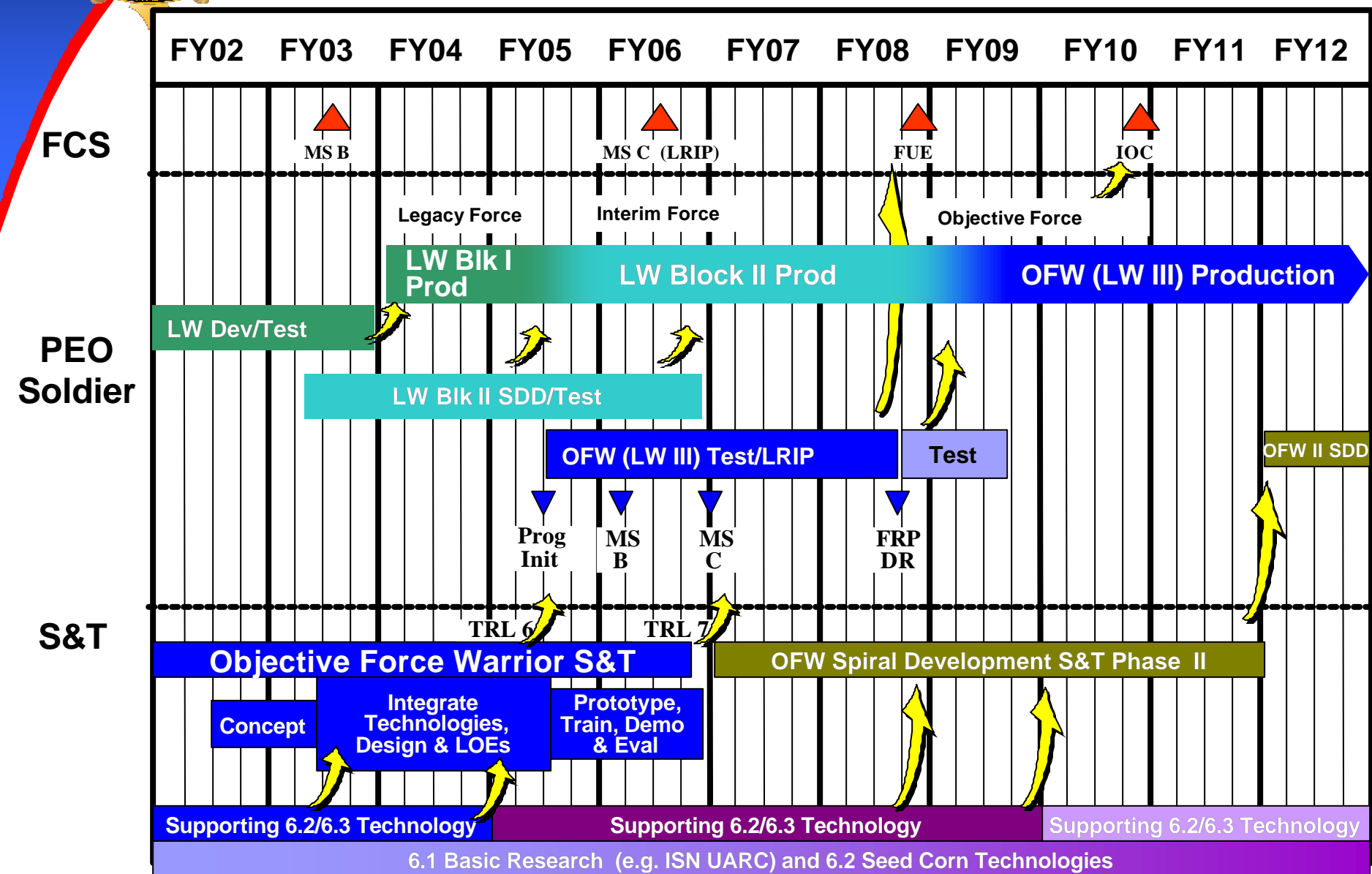


- **Integrated Combat Suit & Headgear**
  - Ultra-Light, Novel Integration
  - Full Spectrum Protection
  - Signature Management (Near & Far IR)
  - Directional Long Range Hearing
- **Fused Thermal, I<sup>2</sup> Integral with Headgear**
  - High Resolution Color Display
- **Unmanned Aerial Vehicle**
  - Organic to Warrior Team
  - Man-packable and/or Mule Launched
- **Robotic Mule**
  - Reduce Soldier Carried Weight to 40-50 pounds
- **Physiological & Medical Sensors & Algorithms**
- **Micro-Climate Cooling & Heating**
- **Customized Voice, Tactile, Visual, & Auditory Human Interface**
- **Embedded Training & Rehearsal**
  - Netted, Collaborative
- **Human Performance Enhancements**



# Accelerated OFW Acquisition Strategy

## - Meets FCS FUE in FY08 -







# ***OFW Solicitation Highlights***



- **Contracting Vehicle “Other Transactions for Prototypes” Agreement**
- **Bids Received 1 May**
- **Contract Award Estimated For 15 July**
- **PEO, TRADOC, OFTF, ARL, ARI, RDEC, STRICOM and MRMC Representation in Source Selection**
- **“LTI” Concept with two Competing LTIs**
- **OFW LTIs tied to FCS LSI**



# Government/Industry Relationships



- ***Government is Leader in OFW Program Decision Processes***
  - ***Government IPT to review, assess and influence competing Lead Technology Integrator (LTI) OFW concepts***
  - ***Full Government participation on LTI IPTs***
    - ***Appropriate firewalls***
- ***Industry Executes OFW Technology Development***
  - ***Takes direction from OFW TPO***
  - ***Develops OFW Concepts, Explores alternatives***
  - ***Executes design, development and fabrication activities***

**Goal: LTI and Government Team dedicated to provide best solutions for Objective Force Warrior**



# Final Remarks

- **Soldier Domain has Historically been Under-Funded**
  - No Rich Source of Technology Options
- ***“Demonstrating a high level of maturity before new technologies are incorporated into product development puts those programs in a better position to succeed”\****
- ***“It is a rare program that can proceed with a gap between product requirements and the maturity of key technologies and still be delivered on time and within costs”\****
- **OFW Strategy is Consistent with:**
  - Five Independent Panel Recommendations
  - Successful Business and Service Practices

\* 1999 GAO Report: Better Management of Technology Development Can Improve Weapon System Outcomes

## Report to Small Arms Committee

# National Defense Industrial Association (NDIA)

## Armament Division

## 2002 Division Status

14 May 2002



## Small Arms Committee

Value Added Has Been Demonstrated

Leadership to Strengthen the Small Arms Community

Challenge: Adapting Technology, Systems for Transformation

Ensuring Readiness . . . Advancing Superior Capability

## Superior Technology and Systems — Readiness — Affordability

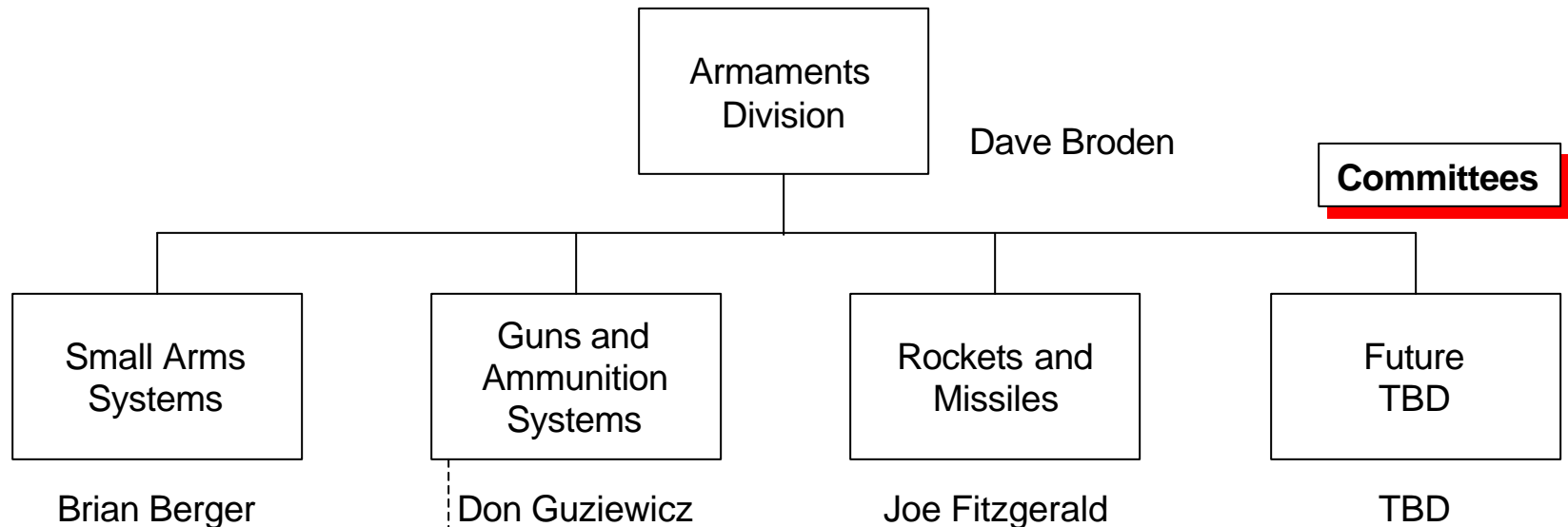
Provide organizational focus to armament systems used by U.S. and allied countries and to address other topics relevant to armament systems

- “Lessons Learned”
- Deficiencies/needs
- Requirements pull/technology push
- Development
- Deployment
- Operations
- International cooperation
- Acquisition
- Affordability
- Supportability

Life Cycle Focus

Acquisition Management

**Objective: Coordinated Focus and Vision for Armament Systems**



Themes, areas discussed; no specific action

**Scope – Area of Interest – Responsibility  
Definition Clarity**

**Seeking Cooperation with Related Sections**

## Small Arms Systems

- Individual weapon(s)
- Crew served weapon(s)  
(e.g.,  $\leq 40\text{mm}$ )
- Full life cycle
- Supportability
  - Training
  - Logistics
- System integration
- Target Acquisition/Fire Control System (TA/FCS)

## Guns and Ammunition

- Medium caliber systems
- Tank systems
- Mortar systems
- Artillery
- Naval gun systems
- Aircraft/helicopter systems
- Platform integration
- System integration
- TA/FCS
- Supportability
- Life cycle

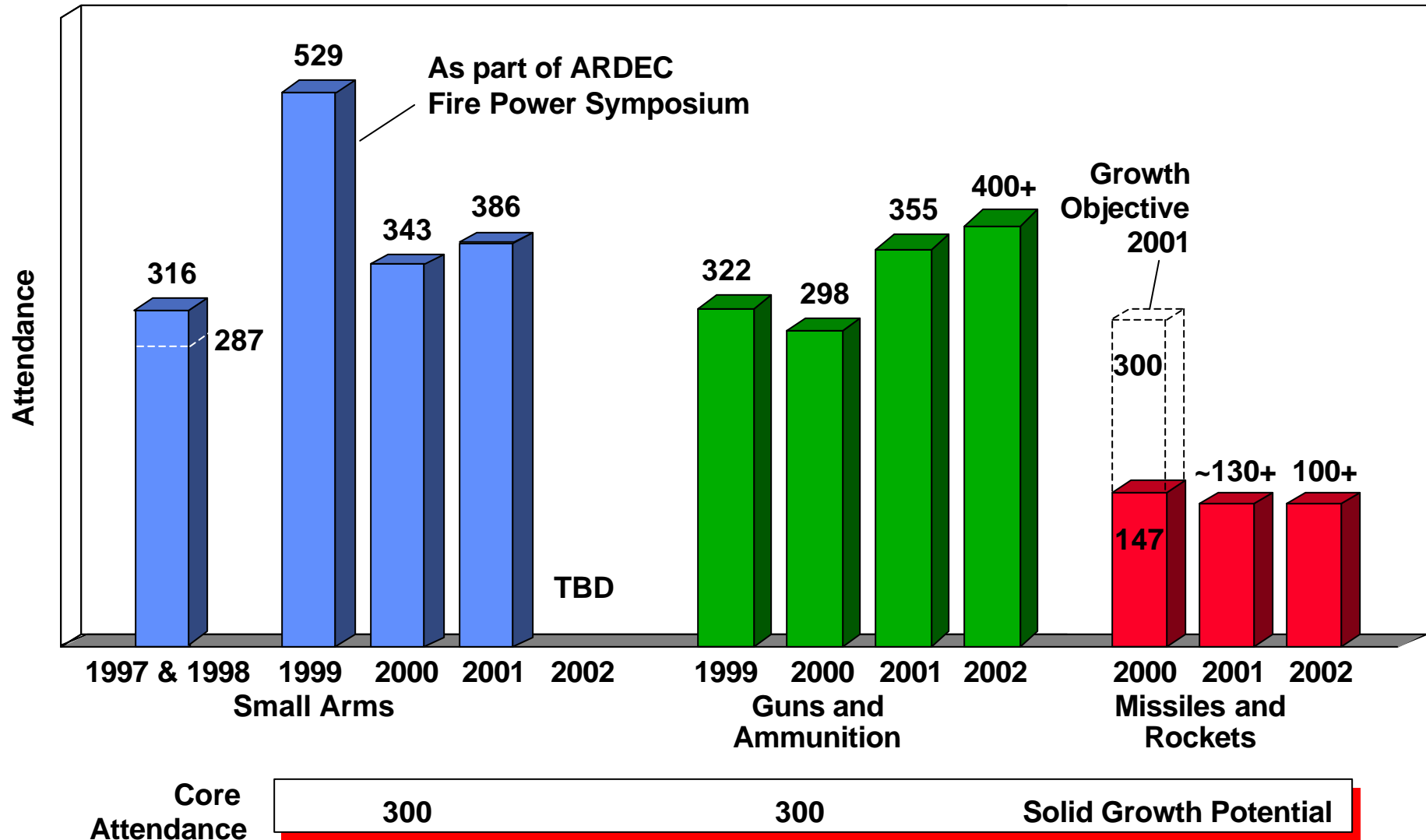
## Missiles and Rockets

- Tactical missiles and rockets
- Shoulder fired systems
- Ground launched
- Aircraft/helicopter launched
- System integration
- Life cycle

**Common Enabling Technologies, Modeling/Simulation, Man-Tech**

**Links to Other Committees**

# Armament Division Attendance Summary





## Forum of Communications

Technology

Systems

Operations

Demonstrations

Exhibits

Lessons Learned

Requirements/Definitions

Technology

- Requirements Driven
- Technology Driven

System Development/Application

Producibility

System Engineering – Assessments – Measuring Performance

Readiness – Superior Capability

## Activities Supporting Small Arms Community

- Strong symposium programs
- Exhibits supporting readiness and innovation
- Continuing effective use of demonstrations
- Committee of Small Arms Producers (CSAP) leadership
  - Assess issues and approaches to maintain/strengthen small arms readiness . . . industry base . . . DoD activity
  - “Small Arms Center of Excellence”

## National Small Arms Center

- Study, plans, and recommendations in process
- Similar to Warheads and Energetic Technology Center (WETC)
- Go-ahead October 2002 if approved — comments welcomed

## Maintaining Legacy Readiness and Achieving the Objective Force Vision

**Future Combat System**

**Objective Force Warrior**

**Applying Technology, Integration, Products to Multiple Needs**

# Synergistic Themes

**Small Arms Systems**

**“21<sup>st</sup> Century Military Operations and Technology”**

**Guns and Ammunition**

**“Innovation for Rapid Deployment and Fielding”**

**Missiles and Rockets**

**“Applying Technology for Future Warfare”**

**Implementing the Themes**

**Responsive to Transformation**

**Objective Force**

FCS  
OFW

**Linking Our Resources Achieves the Goal**

# Small Arms Committee = Supporting the Vision

## Legacy Systems

- Readiness
- Product improvement
- Lightweight capability

## Objective Family

- OICW
- OCSW
- Development/qualification/FUE

## Future Technology/Systems

- Light Fighter Lethality (LFL)
- Technology enhancement
- Netted fires

## Objective Force

- Definition
- Development
- Introduction
- Spiral development

### Challenge

- Defining small arms systems for Objective Force
- Networked firepower
- Apply advanced situation awareness

**Linking – Government and Industry – Achieving Objectives**



## Small Arms Committee Challenges

- Understanding and responding to vision
- Addressing **“Soldier as a System”** including lethal elements
- “Outside the box” approach to systems
- Innovation → operations, integration, technology
- Effective technology insertion with “value added”
- Applying spiral development
- Ruggedness
- Affordability
- Knowledge transition and mentoring

**Linking and Integrating with Objective Force  
Strengthened by Linking with Other NDIA Elements**

## Ensuring Capability Readiness Today and in the Future

**Innovation**

**Responsiveness**

**Openness**

**Partnerships    Industry ® Development ® User**

- Responsive to user operational concepts
- Readiness today and future
- Technology assessment and evolution
- Management and engineering processes
- High quality
- Affordability
- Knowledge transition mentoring

# Armament Division Strategic Plan 2002

## “Challenges”



- Involve the user community effectively
  - Presentations and committee membership
- Focused attention to DoD initiatives to ensure responsiveness/awareness
  - Transformation
  - Objective Force
    - Future Combat System (FCS)
    - Objective Force Warrior (OFW)
- Relevant topics and executing Value Added STUDY with “meaty” recommendations
- Synergistic dialogue with other NDIA divisions/sections
- Linking common benefits sections to chapters

**Response to Challenge → Response to DoD Initiatives**  
**→ Ensure Value Added**  
**→ Establish Partnerships**

- Open “outside the box” solutions which can be “realized”

**No Luddites!**

- User linkage → adapt systems to evolving threats/scenarios and operational needs
- Leveraging synergism
  - Technology
  - System integration
  - Netted systems benefits
- Spiral development benefits

**• Answer “What is Armaments Division Role in Homeland Defense?”**

- Committee participation and leadership
- NDIA linkage: Divisions — Committees — Chapters

- Objective:** International cooperation and integration of symposiums benefiting industry and Department of Defense to encourage partnerships for development, production, and interoperability
- Approach:** Coordination of NDIA Armament Division programs with “Symposium at Shrivenham” The Royal Military College of Science

**European Small Arms and Cannon Symposium**  
**27–29 August 2002**



## Small Arms System

- Operational synergism
- Technology commonality
- Convergence in Systems Integration
- Network applications

## Guns and Ammunition

## Missiles and Rockets

**Complimentary Technology, Integration, and Operations**

**Leveraging Adds Value Throughout Life Cycle**

## NDIA Focus

### Addressing Issues Critical to Small Arms Committee

## Armament Division Focus

- Strong interest and participation
- Linked to key DOD and service strategies
- Effective use of exhibits and firing demonstration
- Transitioning membership and participation profile

### Establishing a Vision for 21<sup>st</sup> Century Partnership

### Applying System Synergism to Meet Transformation Goals

- Funding America's defense
- Protecting the Homeland
- Ensuring the health of the defense industrial base
- Improving training and logistics support
- Reforming international trade processes and cultivating foreign relationships
- Focusing on human capital
- Establishing and maintaining information dominance

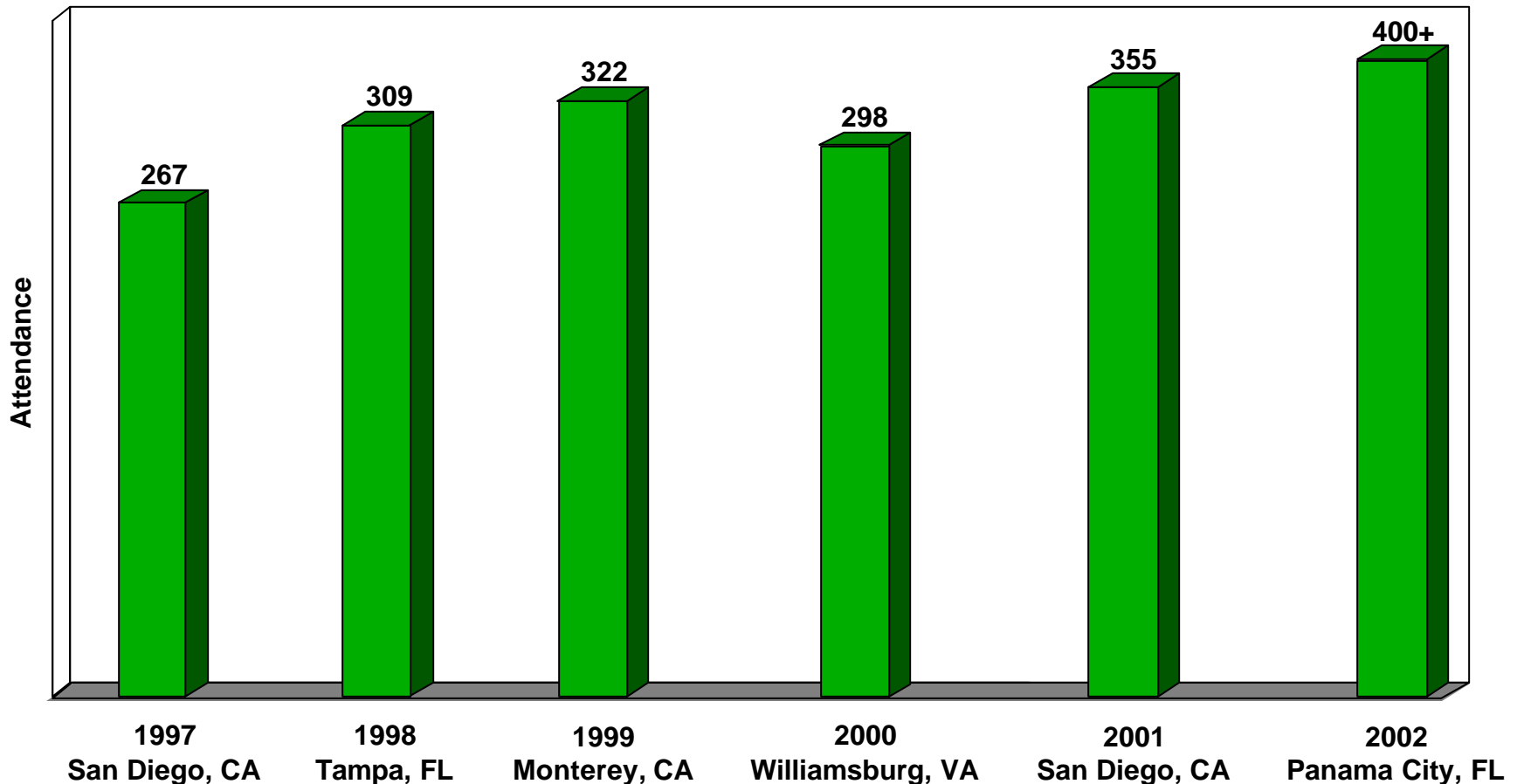
**Issues are Relevant to Small Arms Committee**

# Armament Division Section Attendance



## Guns and Ammunition

- Stable interest
- Balanced community
- Evolving Section scope to expand participation
- Integrating Munitions Division



**2002 International Infantry & Joint Services  
Small Arms Systems Section Symposium  
Exhibition & Firing Demonstration  
21st Century Military Operations and Technology**



***Program Executive Office  
Soldier***

***Soldier Systems Architecture  
“The Soldier As A System”***

**15 May 2002**

**Mr. Dan Causey, Jr.  
PH- (703) 704-1410 DSN 654  
FAX- (703) 704-1110**

**E-mail: [dan.causey@peosoldier.nvl.army.mil](mailto:dan.causey@peosoldier.nvl.army.mil)**





# The Need For PEO Soldier

*To Treat The Soldier As A System & Sponsor Soldier-Centric Design*

**1980's & 90's**

**1999-2000**

**2002**

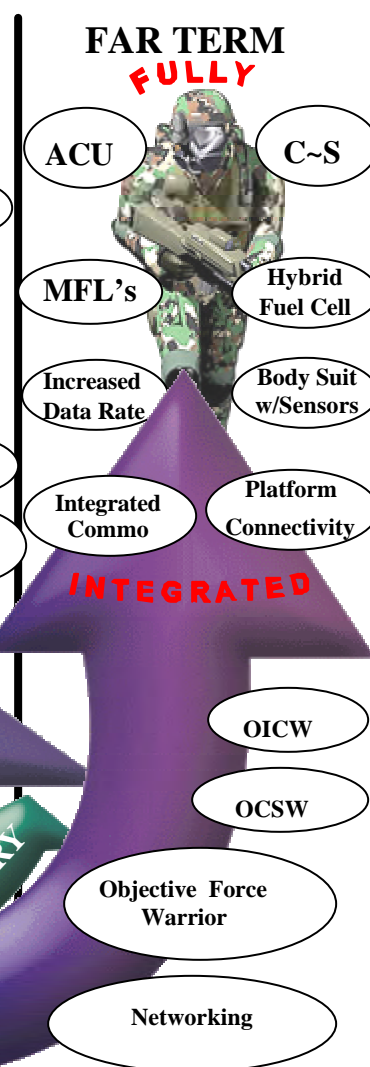
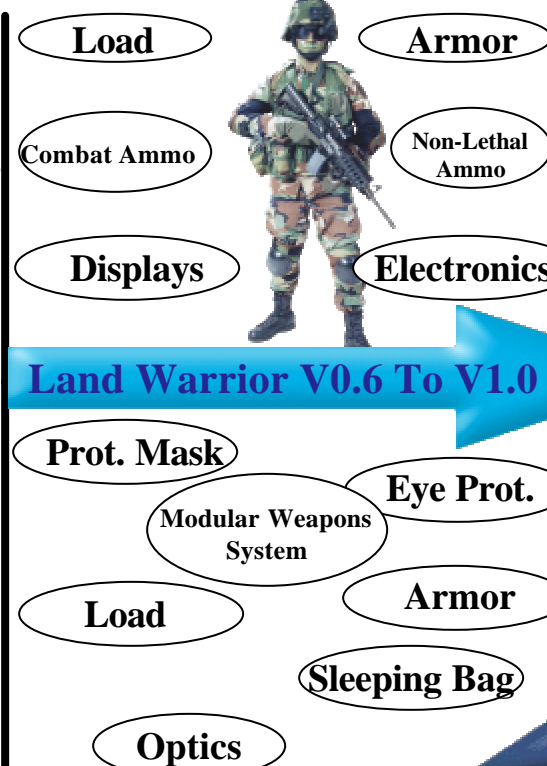
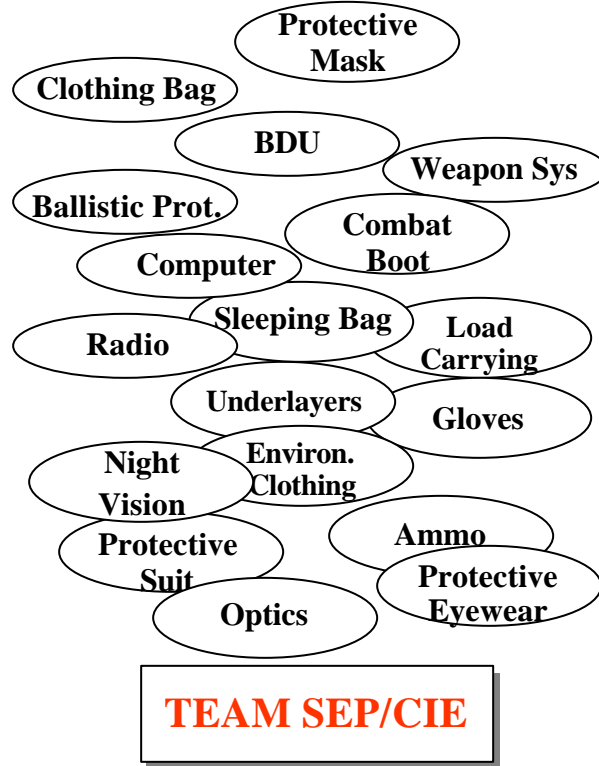
**2008**

## Chaos We Started From

## Initial Steps We Made

## We Are Now

## We Are Going

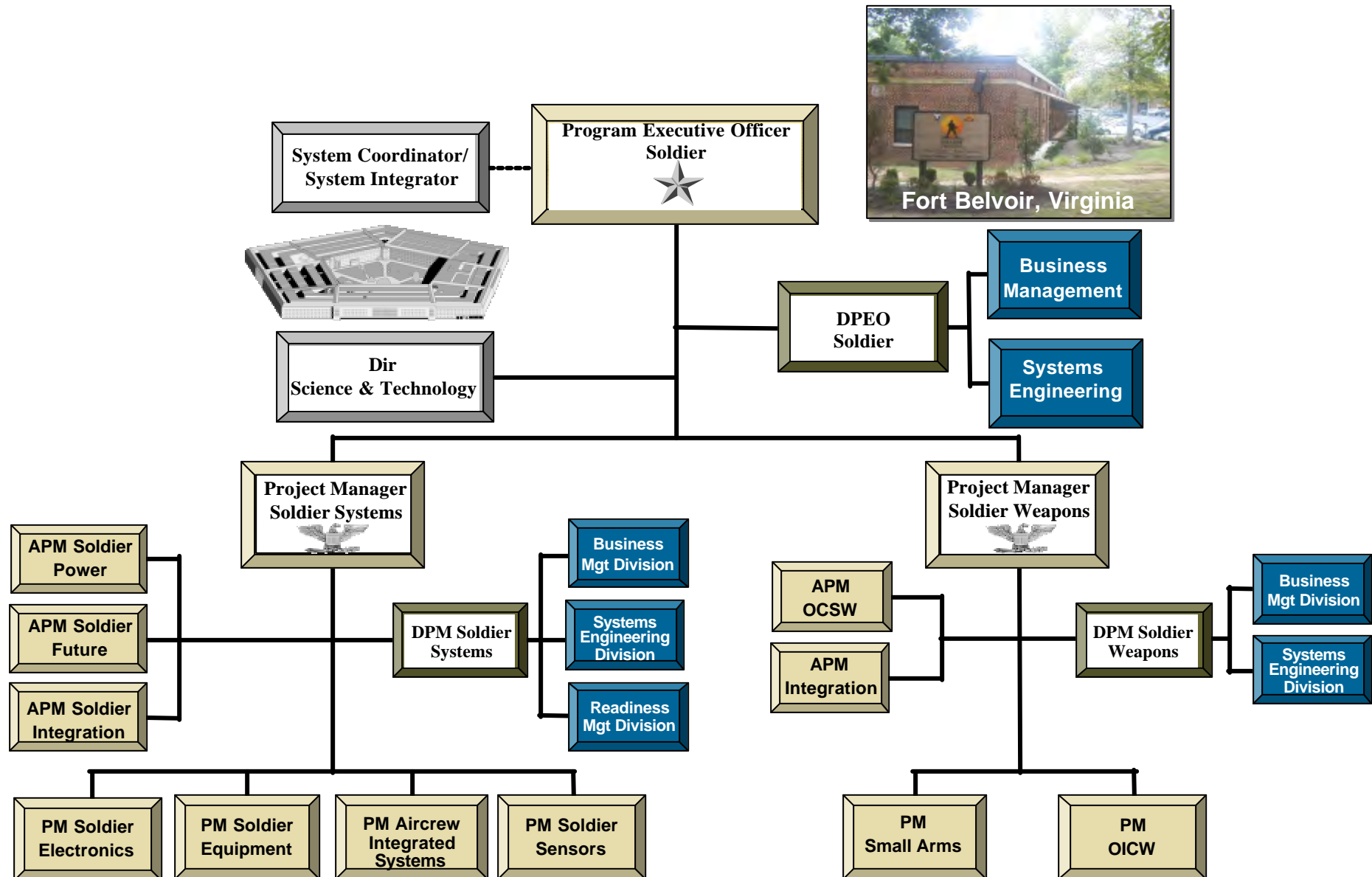


*Soldier Systems Architecture*



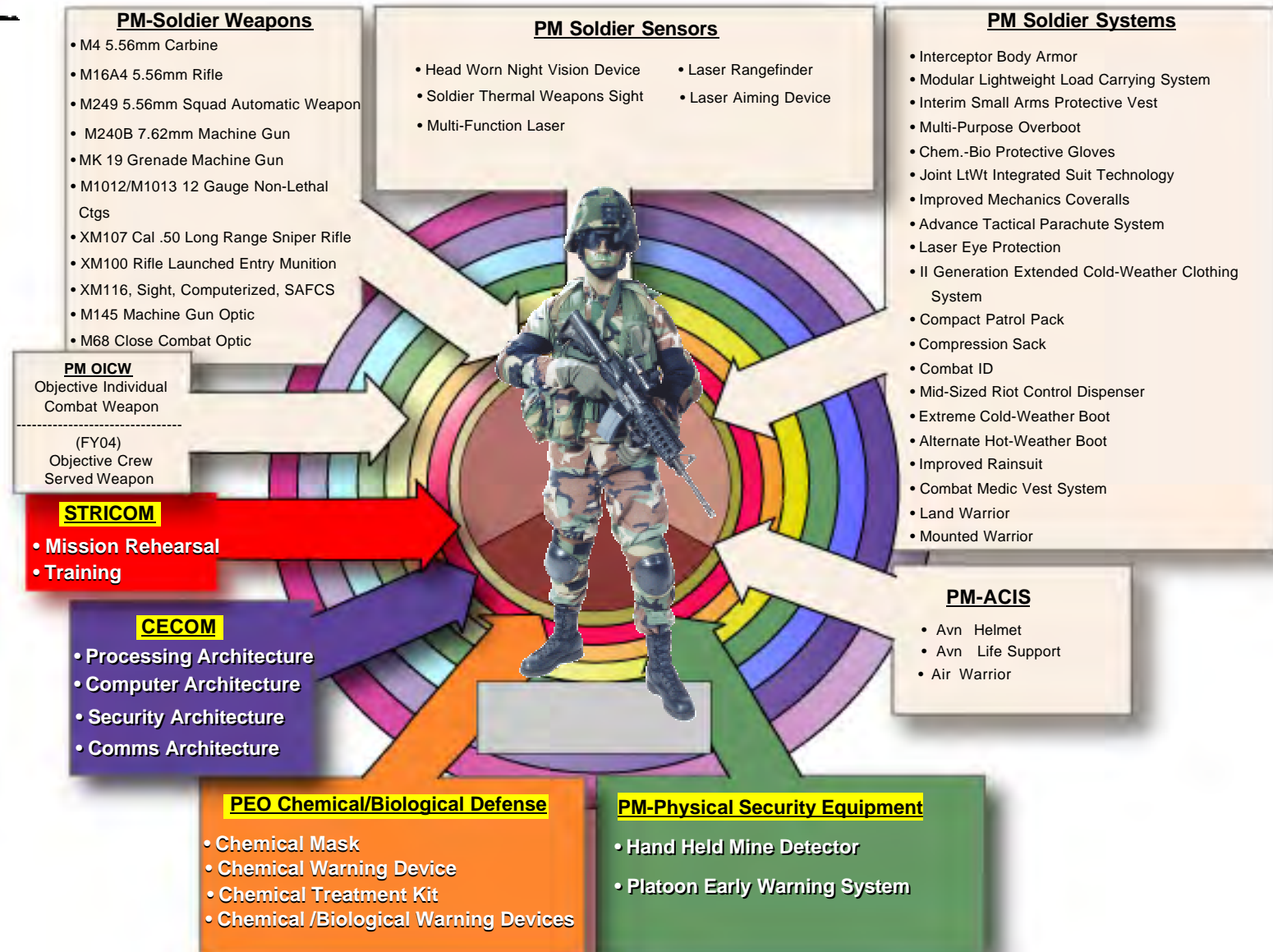
# *Program Executive Office Soldier*

## *Who We Are, Where We Are, What We Do*





# *Soldier Systems Integration Focus*



**Soldier Systems Architecture Integrates 346 Programs Internal To PEO Soldier & Countless Others Externally!**



# ***Soldier Systems Architectural Approach***

## ***The Path From “Standalone” To “System-Of-Systems”***

**Fully Integrated Soldier Systems:**  
A “Uniform” That Comes With  
Computing/Connectivity Built In!  
Same Core Functionality In  
Garrison/Field/Fight Situations!  
Common Hardware & Software!  
In Peace, Soldiers Are “On Line”  
Not In Line! In Conflict, All Parts  
Work Together – From Weapons To  
Comm’s & From Soldier To Vehicle!

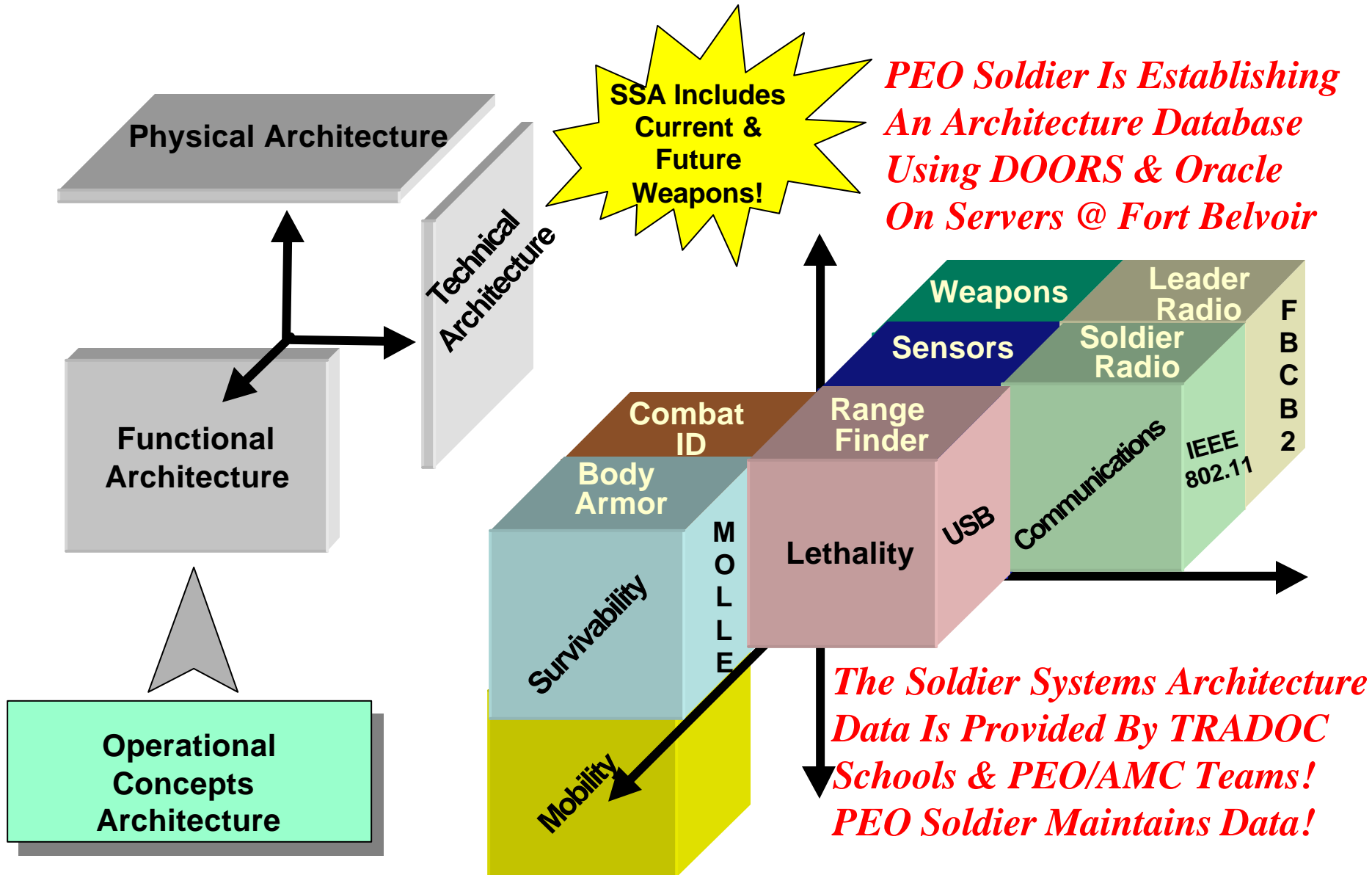


**Soldier Systems Architecture = Work, Train, & Fight With Integrated Equipment!**



# *Establishing The Soldier Systems Architecture*

## *Technology Management Tool For Soldier-Centric Design!*

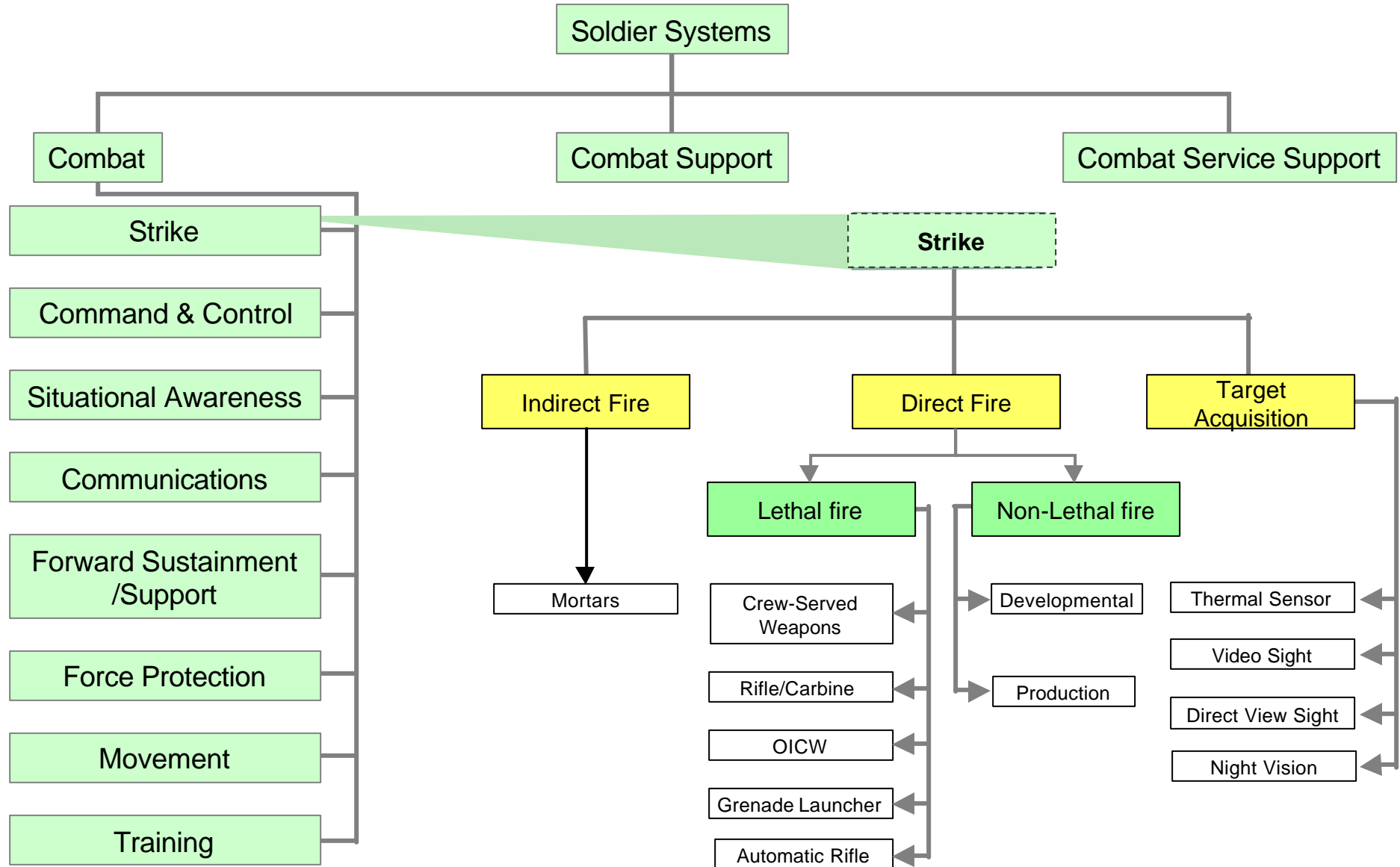






# *Soldier Systems Architecture*

## *Work Breakdown Structure*





# PRODUCT MANAGER SMALL ARMS

**PM SMALL ARMS**



**M19 Grenade  
Machine Gun**



**M16A4**



**NL Bursting  
Hand  
Grenade**



**M84 Stun  
Grenade**



**M249 SAW**



**M4 Modular Weapon System**

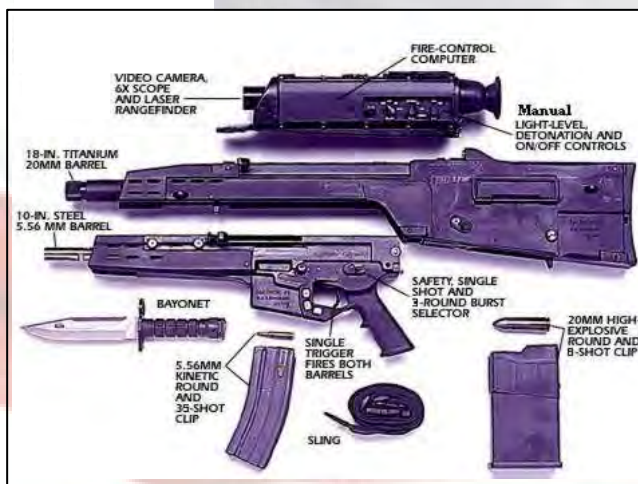
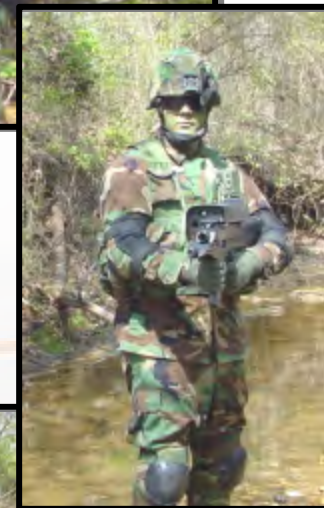
**ACAT III**



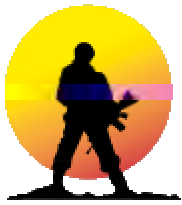
# PRODUCT MANAGER OBJECTIVE INDIVIDUAL COMBAT WEAPON (OICW)



Three different 20mm ammunition types for the OICW. From Left to Right: Bursting munition, High Explosive, Target Practice



ACAT II



# **ASSISTANT PRODUCT MANAGER OBJECTIVE CREW SERVED WEAPON (OCSW)**



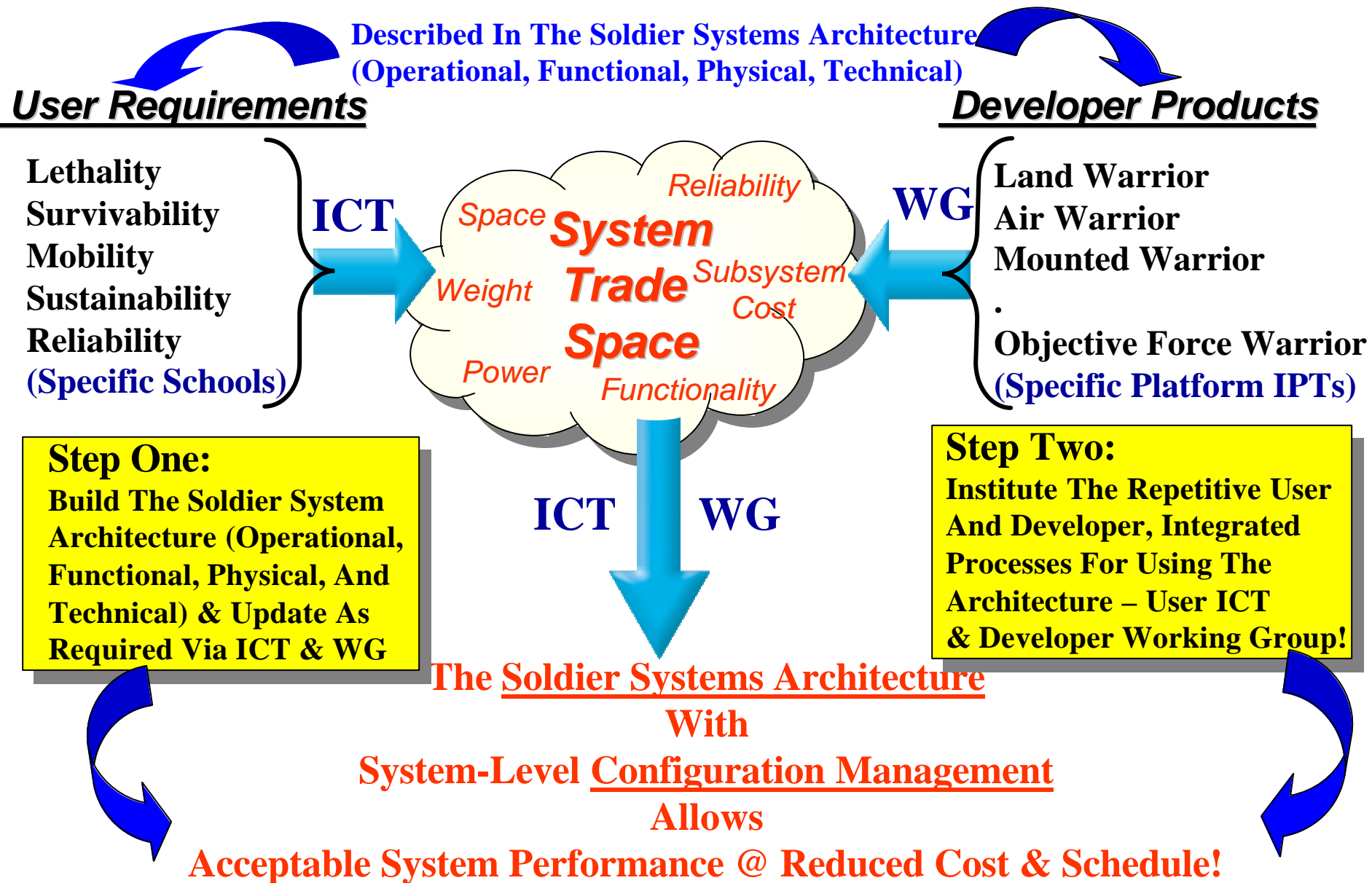
**Program in S&T and will transition to  
PM Soldier Weapons in FY04**





# *Championing The Soldier As A System*

## *Implementing The Two Teams (ICT & WG)*





# ***Objective Force System of Systems Soldier-Centric Architecture***

**Objective Force  
System of Systems  
Based On A  
Soldier-Centric  
Architecture**

**Future Combat System (FCS)  
Objective Force Warrior (OFW)  
FCSS**

**Hardware  
Software  
Legacy  
Systems  
Architecture**

**Integration Of  
Hardware  
Software  
Soldiers**

**The Operational-Functional Reference Model For  
The Objective Force Architecture Integrates Vehicle  
And Soldier Sub-Systems Into A Coherent, Synergistic  
System-of Systems**

**Individual  
And  
Collective  
Soldier  
Systems  
Integration**

**The  
Connected  
Soldier  
Full-Time  
Situation  
Awareness**

**Soldiers  
With  
Personal  
Equipment**

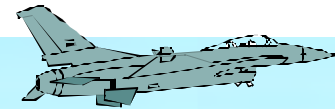


**The Overarching Objective Force Soldier-Centric Architecture Is Required To Support An Army Transformation Based On The Legacy Force Recapitalization, The Interim Force Assimilation, And The Objective Force Implementation Of Technologies As They Become Available. Only Thus Will The Objective Force Be The Stated Achievement Of The Army's Transformation Objective Based On A Soldier-Centric Architecture Capitalizing On Technology For Lethality, Speed, And Agility To Serve As A Deterrent To All Potential Adversaries By Supporting A Wide Range Of Flexible National Command Authority Options.**



# TACOM

Lethality, Survivability, Mobility and  
Sustainment for America's Army



**T**ank-automotive & **A**rmaments **COM**mand

***TACOM Welcome***

**Jerry L. Chapin**  
**Deputy to the Commander**

*Committed to Excellence*



# TACOM / (PEO)<sup>4</sup> Partnership

## World-wide Collaboration Supporting the Warfighter







# TACOM Vision Statement

## Linking the Strategic Direction

### ***ARMY VISION***

- ◆ Soldiers on Point for the Nation: Persuasive in Peace, Invincible in War  
Responsive, Deployable, Agile, Versatile, Lethal, Survivable, Sustainable

### ***AMC VISION***

- ◆ Dedicated and innovative people paving the way in Army Transformation. We will provide the integrated, cutting edge technology and sustainment needed to create a more responsive, agile, strategically deployable and sustainable Army. While unfailingly meeting our worldwide commitments today, our efforts will help posture the nation to meet the broader demands of the newly emerging missions of the 21st century.

### ***TACOM VISION***

- ◆ Providing our soldiers with overwhelming lethality, survivability, mobility, and sustainment for battlefield dominance.



# Supporting Army Readiness



## PRODUCT LINES

### SUPPORT

Capital Value of  
TACOM Equipment  
\$81.7B

2993 Fielded End  
Item NSNs Supported

> 27,000  
Component NSNs

- Combat Vehicles
- Trailers
- Materiel Handling Equipment
- Fuel & Water Dist Equipment
- Chemical Defense Equipment
- Howitzers
- Mortars
- Machine Guns
- Aircraft Armaments
- Rail
- Fuel & Lubricant Products
- Tactical Vehicles
- Construction Equipment
- Tactical Bridges
- Sets, Kits & Outfits
- Shop Equipment
- Large Caliber Guns
- Rifles
- Ammunition
- Demolitions & Explosives
- Watercraft
- Non-Tactical Vehicles

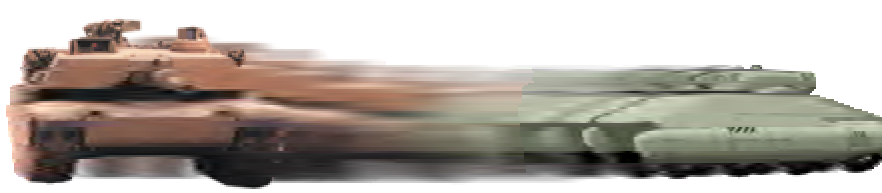
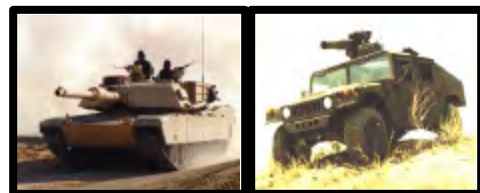
Plus Technology Development for the Objective  
Force

### MAGNITUDE

71% of Army's  
Reportable Density is  
TACOM Supported

81 Allied  
Countries own TACOM  
Equipment

97% of All Army  
Parent UICs Contain  
TACOM Supported  
Equip



The Army's Lead Systems Integrator



# **GOAL #1 - A Revitalized Workforce**

**Leadership, Communication, Organizational Climate, Teaming, Strategic Thinking, and Employee Support**



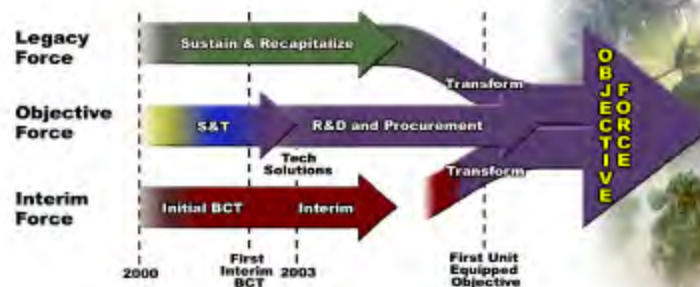
**Idea  
Generators**

**Instilling Desired  
Leadership Traits**



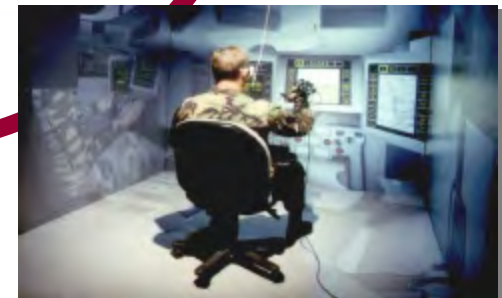
**Idea  
Integrators**

## ***The Army Transformation***



**... Responsive, Deployable, Agile, Versatile,  
Lethal, Survivable, Sustainable.**

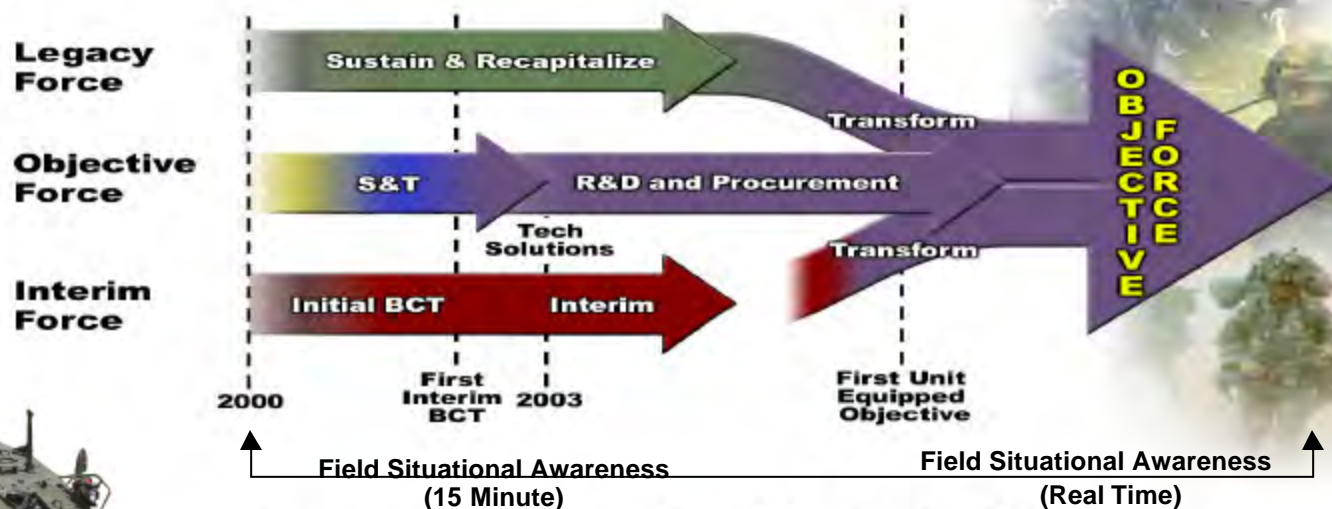
**Building Organizational  
Cohesiveness through a  
Strong Coalition of Leaders**







# The Army Transformation



## INTERIM BRIGADE COMBAT TEAM

TACOM / PEO Team  
Off-the-Shelf Equipment  
Surrogate Vehicles  
Innovative Acquisition Approaches  
Fielding/NET  
Capstone Exercise Support  
Subsequent Fieldings

## INTERIM CAPABILITY

New Technology Insertion  
Recapitalize Legend Systems  
Equipment Redistribution  
Depot Operations  
Force Projection Enablers

## OBJECTIVE FORCE

Technology Breakthroughs  
Future Combat System  
Anticipatory & Deployable Logistics

*... Responsive, Deployable, Agile, Versatile, Lethal, Survivable, Sustainable.*

# ***The Requirement to Transform***



- < Security Challenges of the 21<sup>st</sup> Century
- < Pace and Proliferation of Technology
- < Compelling Need to Respond More Rapidly & Decisively Across the Full Spectrum of Military Operations

***The Army has a Nonnegotiable Contract with the American People to Fight & Win our Nation's Wars***

# The Objective Force

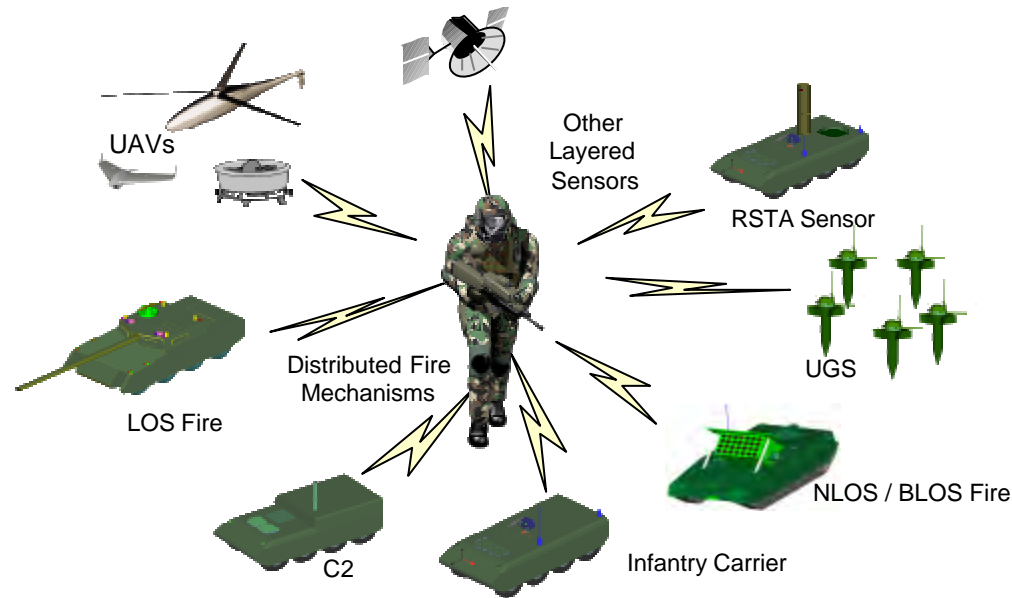


- < **Full Spectrum** – general purpose forces with special purpose capabilities, dominant at every point on the spectrum as a member of the Joint Forces
- < **Characteristics** – responsive, deployable, agile, versatile, lethal, survivable, sustainable
- < **DTLOMS-I<sup>3</sup>** – synergistic advances in doctrine, training, leader development, organization, materiel, Soldiers & installations
- < **Enablers** – self-aware and adaptive Soldiers and leaders, network centric force, and advanced technology
- < **Soldiers** – center piece of our formations

*The XXIst Century Army*

# ***Future Combat Systems (FCS)***

***FCS is the networked system of systems that will serve as the core building block within all maneuver Unit of Action echelons to develop overmatching combat power, sustainability, agility, and versatility necessary for full spectrum military operations.***



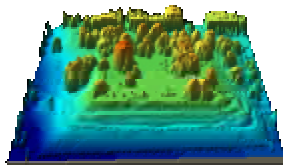
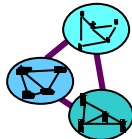
***The “Big Five” Plus... in One Unit***



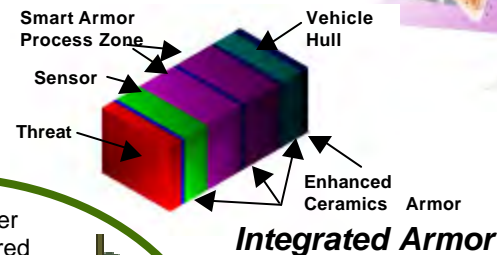
# FCS Technologies in Development

## C4ISR

- Organic 3D Targeting
- Mobile C3
- FCS Comms - Multi-node high/low band
- Tags
- All weather OAV sensor – JIGSAW



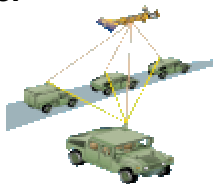
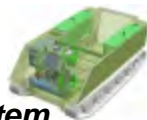
## Survivability



Signature Management

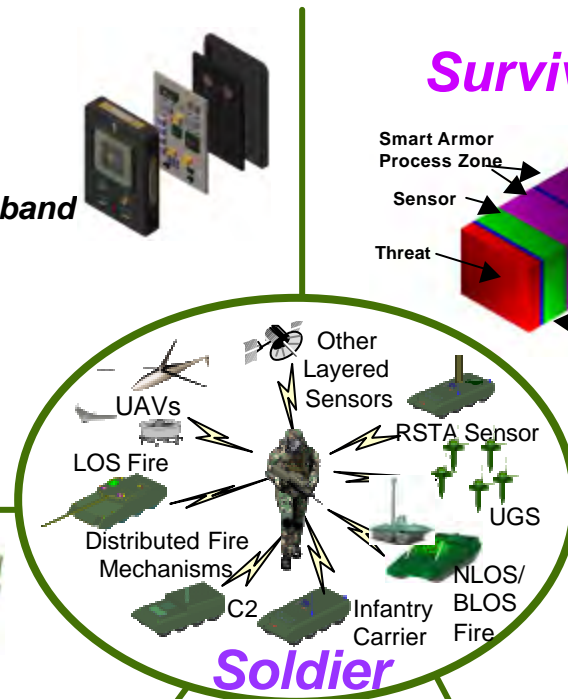
## Mobility

- Combat Hybrid Power System
- Advanced Diesel



## Human Engineering

Crew Integration & Automation Testbed



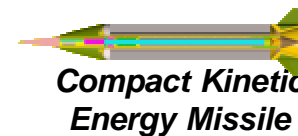
## Soldier



## Lethality



Networked Fires



Compact Kinetic Energy Missile

## UAVs



Follower UGV

## Robotics

# Objective Force Partnership





# Boeing/SAIC FCS LSI Team

## Program Manager (PM)

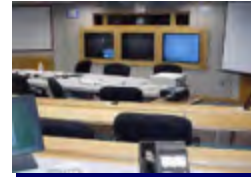
Jerry McElwee (Boeing)  
Washington, D.C.

## Deputy PM

John Gully (SAIC)  
Washington, D.C.



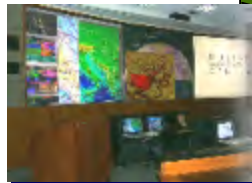
Boeing  
Seattle, WA  
Program Administration  
Systems Engineering  
& Integration



SAIC  
Philadelphia, PA  
Supportability



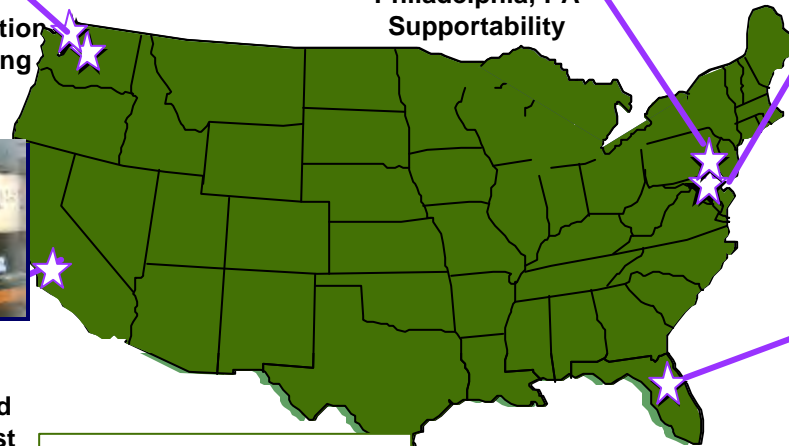
Boeing  
Arlington, VA  
PROGRAM MANAGER  
Systems Engineering  
& Integration  
Combat Systems



Boeing  
Anaheim, CA  
C4ISR Integrated  
Simulation & Test

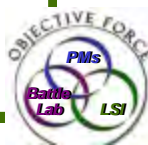


SAIC  
Orlando, FL  
Training Systems



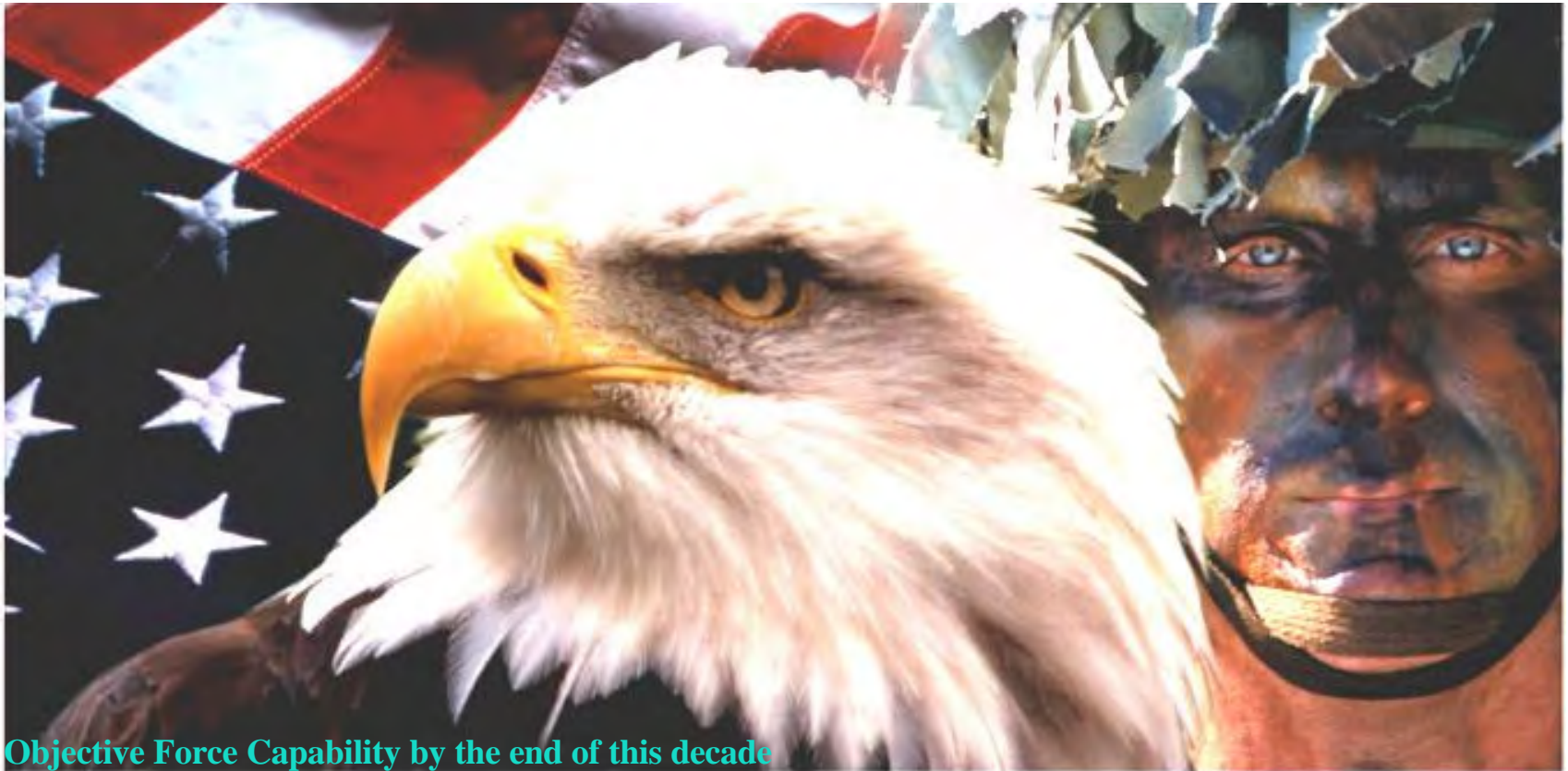
## Key Deliverables

- < **System of System Architecture**  
supports interoperability with legacy and Joint systems
- < **Advanced Collaborative Environment**
  - early user involvement in design
  - supports SBA
  - supports Test and Evaluation
- < **C4ISR Open Architecture**  
allows upgrades as technologies mature
- < **Demonstrations during CTD**  
addresses key risk areas
- < **Management Plan**
  - supports competitive environment throughout life cycle
  - affords immediate start upon award





# ***The U.S. Army Tank-automotive and Armaments Command***



Objective Force Capability by the end of this decade

**Committed To Excellence...**

**Routinely**



# National Defense Industrial Association Small Arms Symposium **Sensors for Small Arms Munitions**

MAY 2002

**Tomas Cincotta**

U.S. Army CECOM RDEC NVESD  
AMSEL-RD-NV-LW-SS  
10221 Burbeck Road  
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Fort Belvoir, VA 22060

**Ed Moody**

RAND  
1700 Main Street  
Santa Monica, CA 90407



# Sensor Integration for Small Arms Smart Munitions



What advantages can a Small Arms Smart Munition offer to the 21<sup>st</sup> Century Soldier?

- Increased Lethality (High Probability of Incapacitation, P(I) )
- Simplicity in Operation (Locate Target, Point, Fire and Forget, not laser designated)
- Effective For Multiple Enemy Positions (Moving, Stationary, in Defilade)
- Lightweight Weapon System (Soft-launched autonomous munition)

## Projectile Sensor Requirements

Small Size, Low Weight  
Passive Operation in Day & Night  
Sensitivity (*Range dependent*)  
Response Time (*Velocity dependent*)  
Autonomous Target Detect and Engagement  
Low Power  
Easy to Manufacture

USER



FLIGHT PATH

Sensor  
On-Board

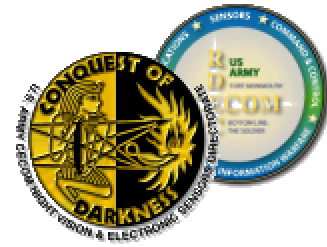
MUNITION

AIR BURST

SENSOR  
FIELD OF VIEW



# Concept of Operation For Small Arms Smart Munition



## Sequence of Events on the Fire Control System (individual weapon)

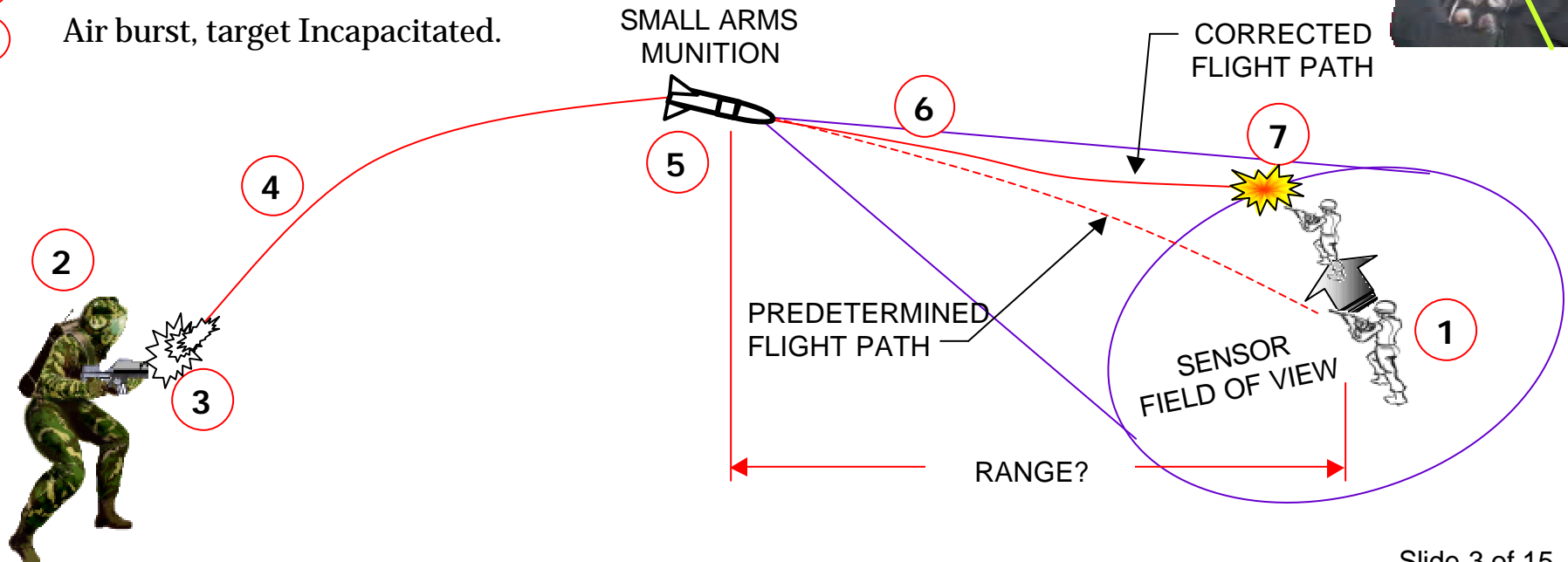
- Detect target and Acquire target location information.
- Compute flight trajectory, target image(s), Download to munition.
- Elevate weapon, Soft-launch munition.

## Sequence of Events on the Small Arms Munition

- Follow predetermined flight path to known target location.
- Activate sensor and Look for target.
- Detect target, Maneuver to target.
- Air burst, target Incapacitated.

### 21<sup>st</sup> Century Visionary Soldier

- Individual Weapon
- Electronic Compass
- Laser Rangefinder
- Infrared Sensor







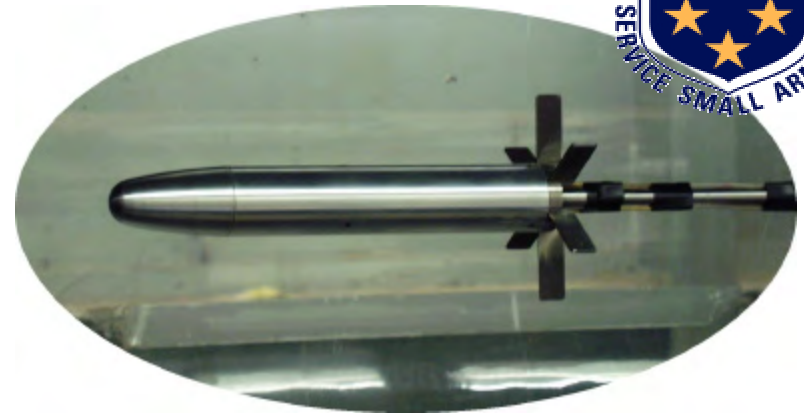
# Light Fighter Lethality (LFL) Small Arms Smart Projectile Example



**Need Munition Characteristics to Focus Sensor Development/Specifications**

**Propose the Light Fighter Lethality (LFL) Seeker Projectile being developed by JSSAP**

- Fin Stabilized – Maximum Spin Rate: 6 Hz
- Diameter: 25.0 mm
- Length: 165 mm (6.1") unfolded
- Weight Goal: 0.5 lbs
- Maximum Flight Velocity: 160 m/s
- Maximum Engagement Range: 500 m
- Time of Flight: 4 s
- Target Type: Personnel in Body Armor



**Based on above, Propose Using a 8-12 micron Uncooled Staring Microbolometer Sensor**

**Advantages:**

- + Small Size (no scanning)
- + Low Weight, Low Power (with no TE cooler)
- + Passive, All Weather Operation
- + Medium to High Sensitivity
- + Manufacturing Processes Improving

**Disadvantages**

- Not Spin Insensitive (current pixel design)
- Non-Uniformity Correction (Calibration)
- Sensor Noise
- Thermoelectric (TE) Cooling currently



# Sensor Development Outline



**GOAL:** Detect a personnel target with high probability early in projectile flight to provide adequate range and time for maneuvering.

**FIRST:** Determine the suitable Field of View (FOV) for the optics to fully contain the target based on projectile flight path. Concurrently, design external profile to satisfy aerodynamic stability. (slide 6&7)

**SECOND:** Optimize sensor array size for the given FOV and determine appropriate focal length to satisfy projectile physical constraints. (slide 8)

**THIRD:** Determine thermal time constant to minimize image degradation induced by projectile spin rate. (slide 11)

**FOURTH:** Determine detector sensitivity required to resolve target at sensor turn-on range. (slide 12)

**FIFTH:** Predict detector sensitivity and thermal time constant values necessary to achieve a 70% probability of detection for a personnel target to satisfy the LFL application. (NVTherm Model) (slide 13)

**SIXTH:** Identify any issues associated with the sensor development results. (slide 14)



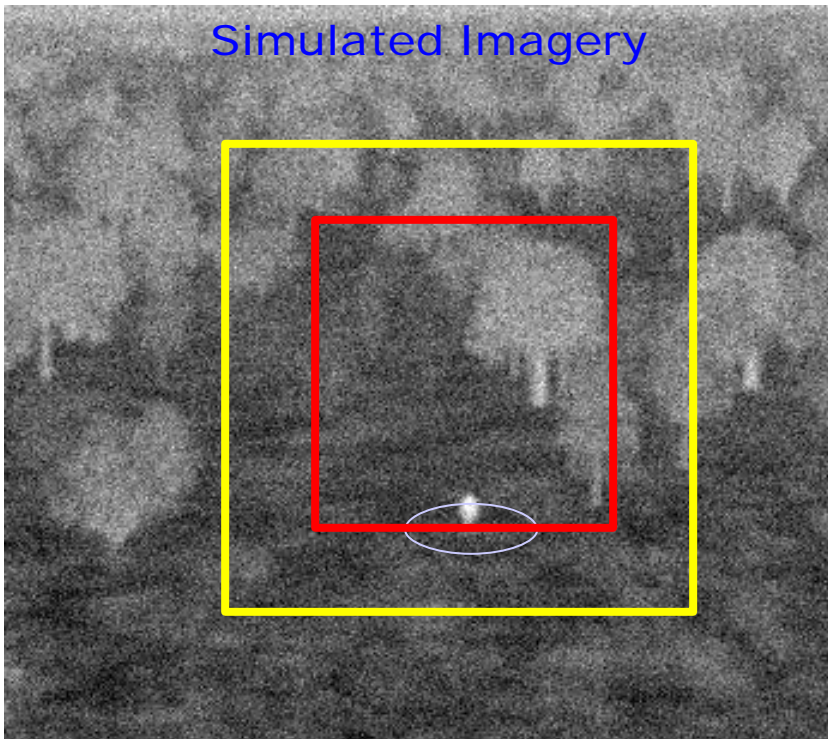
# Field Of View (FOV) Analysis at Sensor Turn-On



(Range: 265m, Altitude: 16.8m,  $-0.11^\circ$ , TOF: 2.2sec)

Range to Target is 235 m

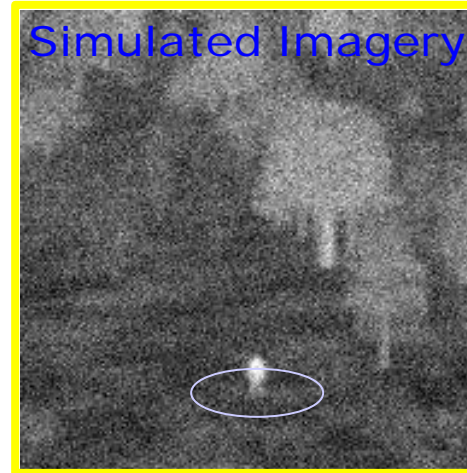
Simulated Imagery



*~10° Field of View*

Circle is how far target could have run in the elapsed time from initial target acquisition to sensor turn-on.

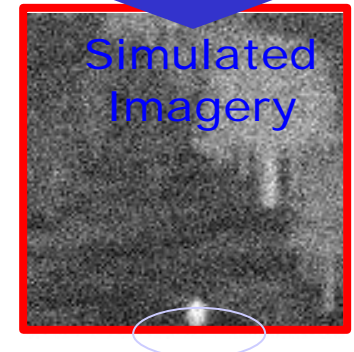
Simulated Imagery



*8° Field of View*

Requires Decreasing  
Projectile Altitude  
Or Later Turn-On!

Simulated  
Imagery



*6° Field of View*

## Field of View Must Encompass

- Target upon turn-on without affecting projectile flight.
- Distance the target can run in available time.
- Errors associated with the targeting devices (such as the laser rangefinder, digital compass).
- Errors associated with projectile flight trajectory.

**10° Is Excessive, 6° Is Too Small in Azimuth, 8° Is Sufficient.**



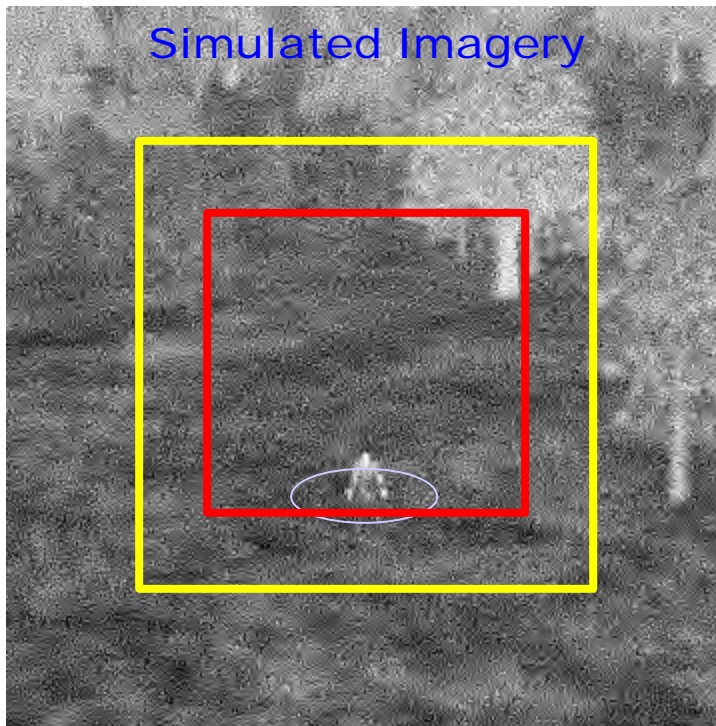
# Field Of View (FOV) Analysis at Closer Range to Target



(Range: 413m, Altitude: 10.8m,  $-4.7^\circ$ , TOF: 3.3sec)

Distance to Target is 87 m

Time to Impact is 0.7 sec

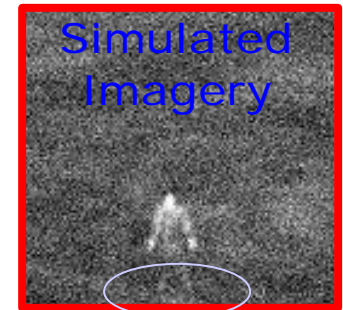


*~10° Field of View*



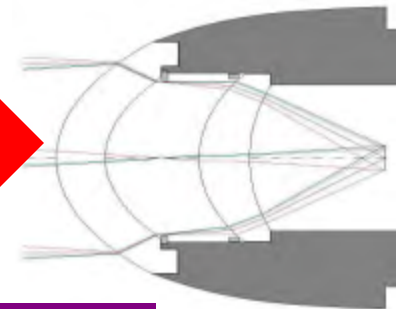
*8° Field of View*

Circle indicates how far the target can run before the projectile reaches the target.



*6° Field of View*

**External Profile  
Satisfies Aerodynamic  
Stability Factors**

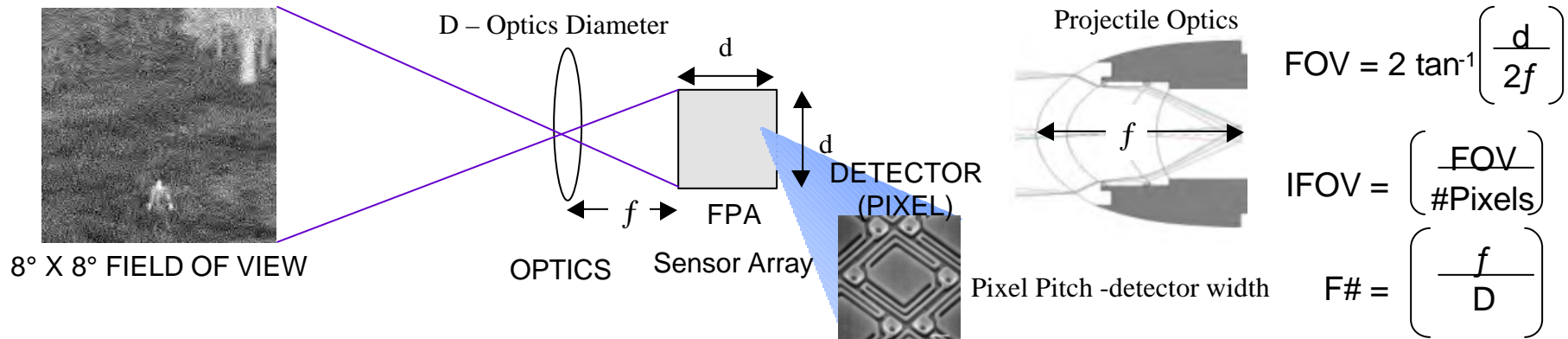


**Shorter Range to Target Reduces Amount of Scene Coverage  
In Addition to Time Available for Projectile Course Correction**





# Focal Plane Array (FPA) Optimization Analysis



**Determine Appropriate Focal Plane Array Size to Best Resolve the Required Field of View.**

**Dependent On:**

• Number of Detectors	Many	Higher Resolution, Small IFOV
	Few	Lower Resolution, Large IFOV
• Pixel Pitch	Large	Large FPA Size, Long Focal Length (f)
	Small	Small FPA Size, Short Focal Length (f)
• Processing Consideration	Many Pixels	More Image Processing per pixel
	Few Pixels	Less Image Processing per pixel

**PERFORMANCE  
TRADEOFF**

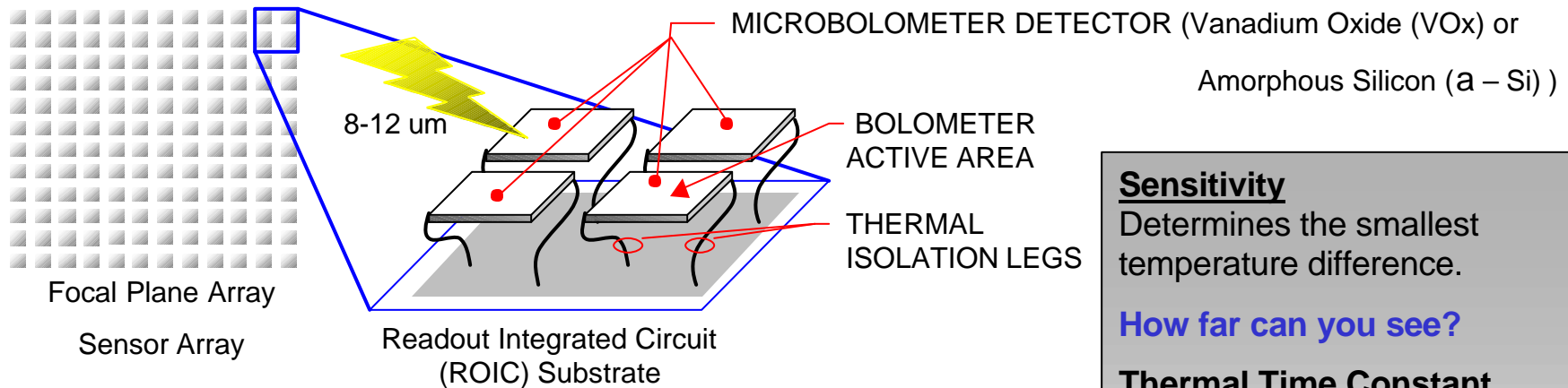
**Desire The Most Compact Optical System That Sufficiently Resolves The Target.**

**Result: 64 x 64 FPA, 25 μm pixel pitch, 11.5 mm (0.45") focal length, 0.13° IFOV, 0.9 F#.**





# Microbolometer Detector Operation and Characteristics



## Microbolometer Detector Operation

- Active Area absorbs incoming Infrared (IR) energy.
- IR energy produces a change in detector resistance across legs.
- Resistance change is sensed by integrating bias current or voltage.
- Resulting detector signal is read out and digitized.

The larger the change in resistance, the more IR energy was absorbed, and the thus the “hotter” the target.

### Sensitivity

Determines the smallest temperature difference.

### How far can you see?

### Thermal Time Constant

Determines detector speed of response by the following equation:

$$t_{th} = C / G$$

where C = Thermal Heat Capacity (J/K)

G = Thermal Conductance (W/K)

### How fast can you see it?

**Sensitivity and Thermal Time Constant are Inversely Proportional Based on Material Properties, Thermal Mass and Physical Geometry.**



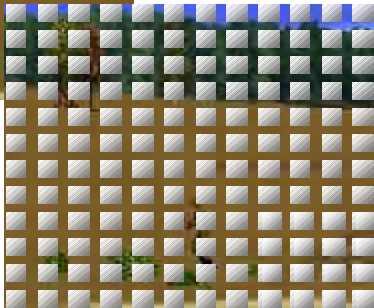
# Issue of Projectile Spin on Sensor Effectiveness



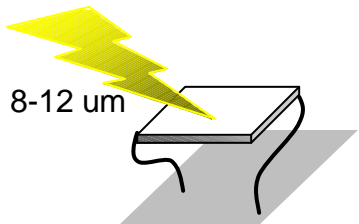
## NO PROJECTILE SPIN



Visible Scene



Scene Imaged  
by Static FPA



8-12  $\mu\text{m}$

IR Energy Contained within  
the IFOV is Absorbed by  
the bolometer.

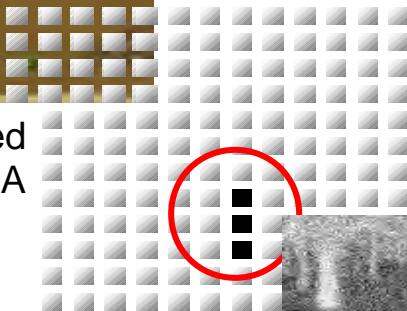


Image Readout



Thermal Image



Visible Scene



Scene Imaged by  
Rotating FPA

## PROJECTILE SPIN

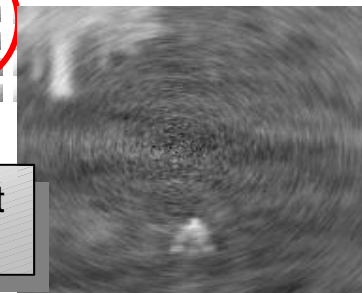
6 Hz Spin =  $2160^\circ$  rotation/second

For single detector  
with  $\tau_{th} = 10\text{ms}$ ,  
scene IFOV rotates  
by  **$21.6^\circ$ !!!**

*Target Contrast  
Decreased!  
Aspect Ratio  
Changes!*

Image Readout

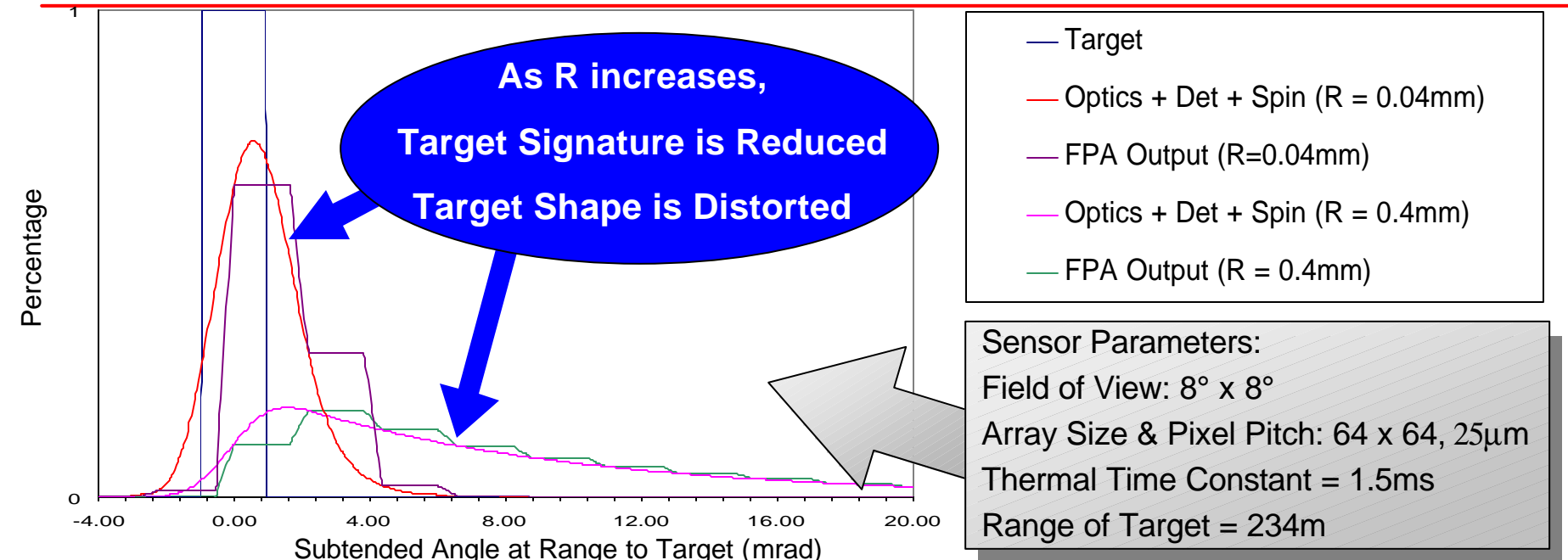
Effect worsens at  
FOV extremes.



Thermal Image

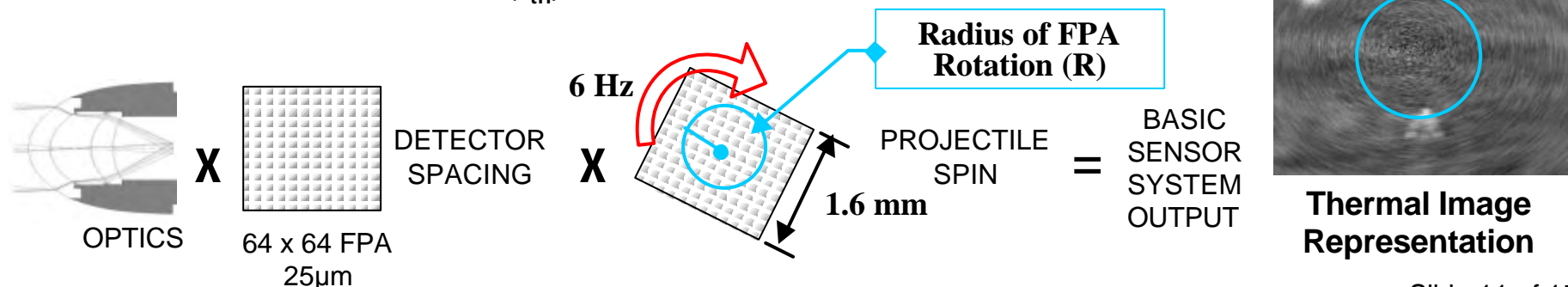


# Projectile Spin Analysis (cont'd)



As Seen Above, Effect Worsens With Larger Radii of FPA Rotation ( $R$ ).

With Thermal Time Constants ( $t_{th}$ )  $> 1.5\text{ms}$ , The Result is More Dramatic.

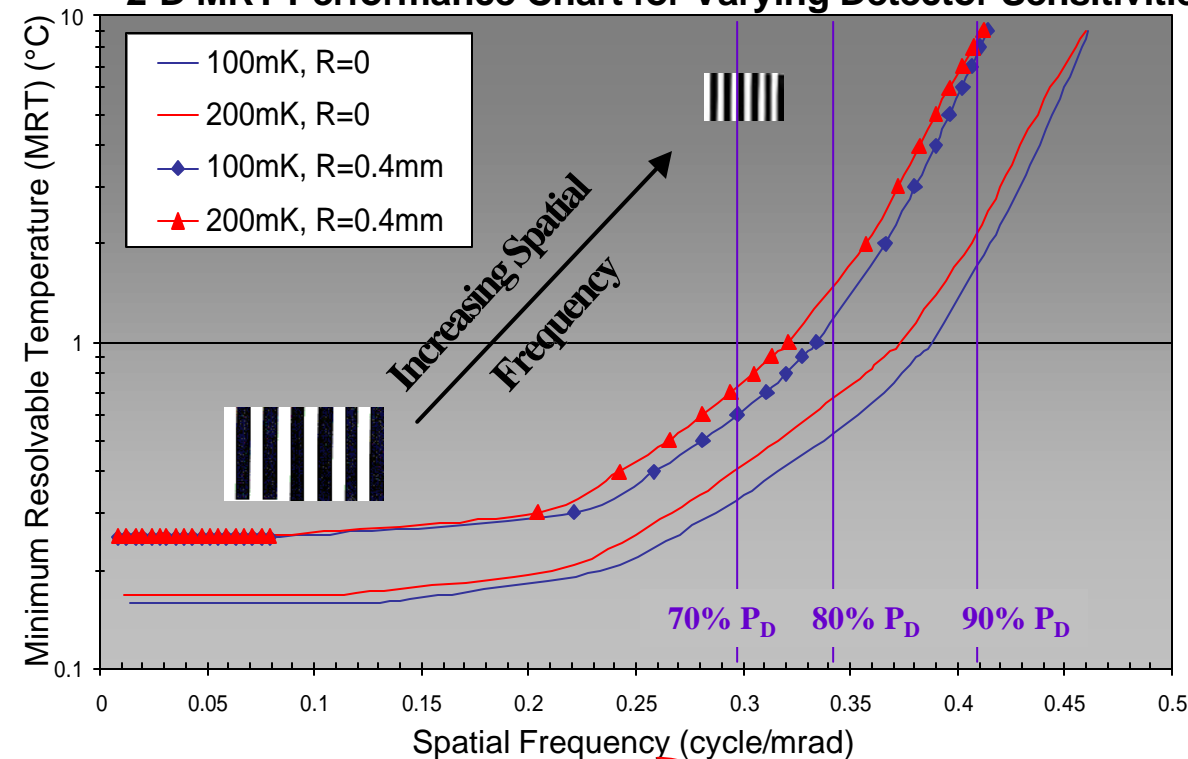




# Required Sensor Performance at Sensor Turn-On Range (234m to target)



**2-D MRT Performance Chart for Varying Detector Sensitivities**



Sensor 2-D MRT

Atmospheric Transmission (0.7km<sup>-1</sup>)

Target-to-Background ? T (1.25° C)

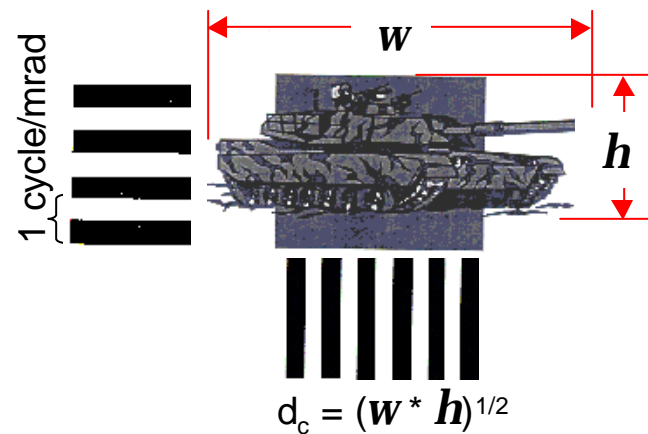
Target Critical Dimension (d<sub>c</sub>) (0.75m)

**Plug into NVTherm Model,  
Output is a Range  
Performance Estimate for  
Probability of Detection**

MRTD is the minimum temperature difference between a standard target and the background that is required in order for a standard observer to just fully resolve the target. It is the best overall indicator of thermal imager system performance.

- FLIR92 Thermal Imaging Systems Performance Model, NVESD, Fort Belvoir, VA, Jan 1993.

## Johnson Criteria





# Verify Sensor Parameters Through Sensor Performance Modeling



## Sensor Parameters

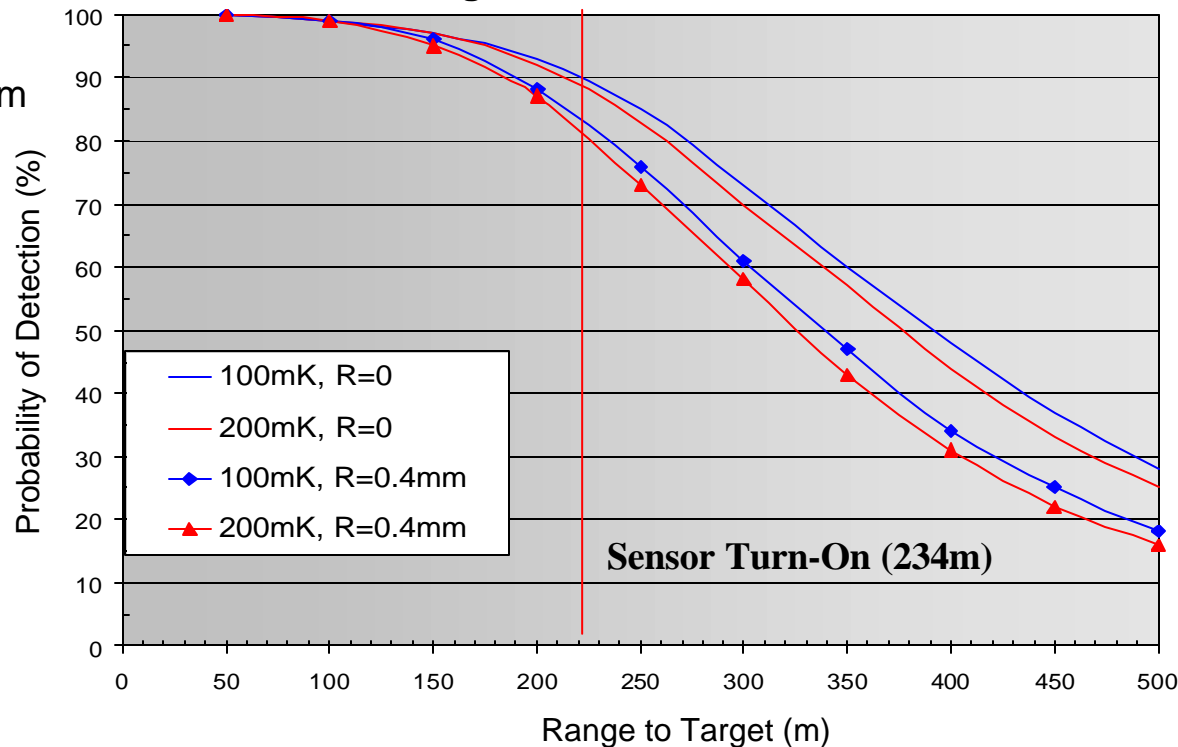
Focal Plane Array Size	64 x 64 pixels
Detector Sensitivity	100-200mK (f/1 @30Hz)
Thermal Time Constant	1.5ms (minimum)
Pixel Pitch	25μm
Field of View	8° x 8°
Focal Length	11.5 mm
F#	0.9

## Range Performance Estimates

Prob. of Detection	100mK	200mK
70%	270m-312m	260m-300m
80%	217m-233m	225m-262m

NVTherm is a computer model that is used to estimate the performance of thermal imaging systems. It was developed by the CECOM RDEC Night Vision & Electronic Sensors Directorate (NVESD), Fort Belvoir, VA.

## Sensor Range Performance from NVTherm







# Sensor Development Issues



## Factors Not Accounted For in Current Sensor Development:

- Software-in-the-loop operation for personnel target detection.
- Verify operational timelines can be satisfied through the interaction of the guidance and control unit to the automatic target detection process.
- Noise considerations(non-uniformity, fixed pattern noise).
- LFL Seeker Projectile flight errors on FOV optimization.
- Target aspect ratio based on projectile Angle of Attack (AoA).

## Impact

Moderate to High

Moderate

Moderate to Low

Moderate to Low

Low (<5° AoA)

## Factors Associated with NVTherm Range Performance Results

- Does not account for software-in-the-loop target detection. Moderate to High
- 70% Probability of Detection is conservative estimate for **man-in-the-loop**. Moderate

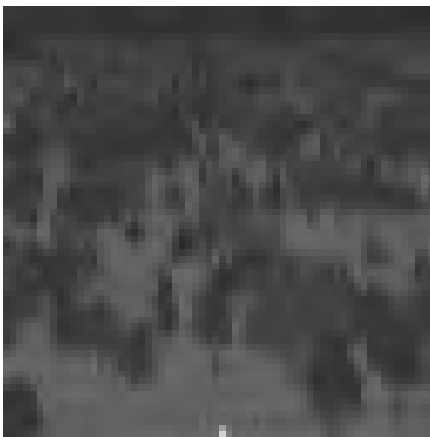
**Software-in-the-Loop Design Integration Will Be Addressed In Future Analysis. However, The Analysis To Date Still Proves That Sensor Parameters Can Be Adjusted To Satisfy The LFL Seeker Projectile Application.**



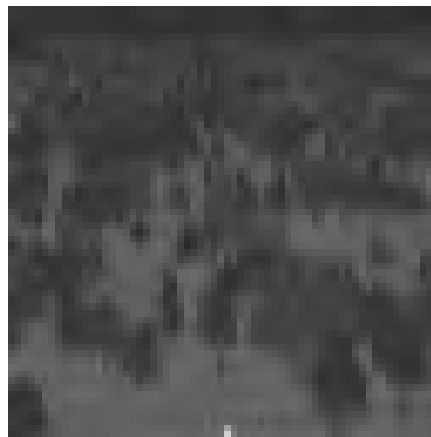
# Summary and Future Work



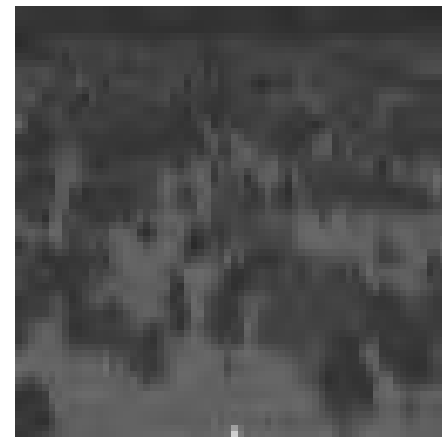
- Investigate Prototype Development of an Uncooled, Small Array Sensor for Use in Smart Munitions.
  - Revise Sensor Parameters To Consider Munition Guidance and Control Capabilities.
  - Uncooled Detector Technologies Have Improved In Recent Years (assuming reasonable temporal response and sensitivity requirements).
  - Electronics Required to Readout the Sensor Images Can Be Produced.
- Investigate Issues Associated with the Software-in-the-Loop issue for Automatic Target Detection.
- Continue Development of the LFL Seeker Projectile Sensor Simulation as a Sensor Analysis Tool.



**LFL Simulation**  
**Real-Time Speed**



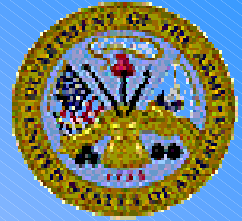
**LFL Simulation**  
**1/3 Speed**



**LFL Simulation**  
**1/10 Speed**



Lethality, Survivability, Mobility and  
Sustainment for America's Army



# **Army-Led, Joint Non-Lethal Weapons Crowd Control & Area Denial to Vehicles Concept Exploration Programs**

**2002 International Infantry & Small Arms Symposium,  
Exhibition & Firing Demonstration**

**21<sup>st</sup> Century Military Operations and Technology**

**14 May 2002  
Atlantic City , NJ**

John Cline  
AMSTA-AR-CCL-D  
U.S. Army TACOM-ARDEC  
Com (973) 724-7317

**T**ank-automotive & **A**rmaments **COM**mand  
*Committed to Excellence*

# OUTLINE

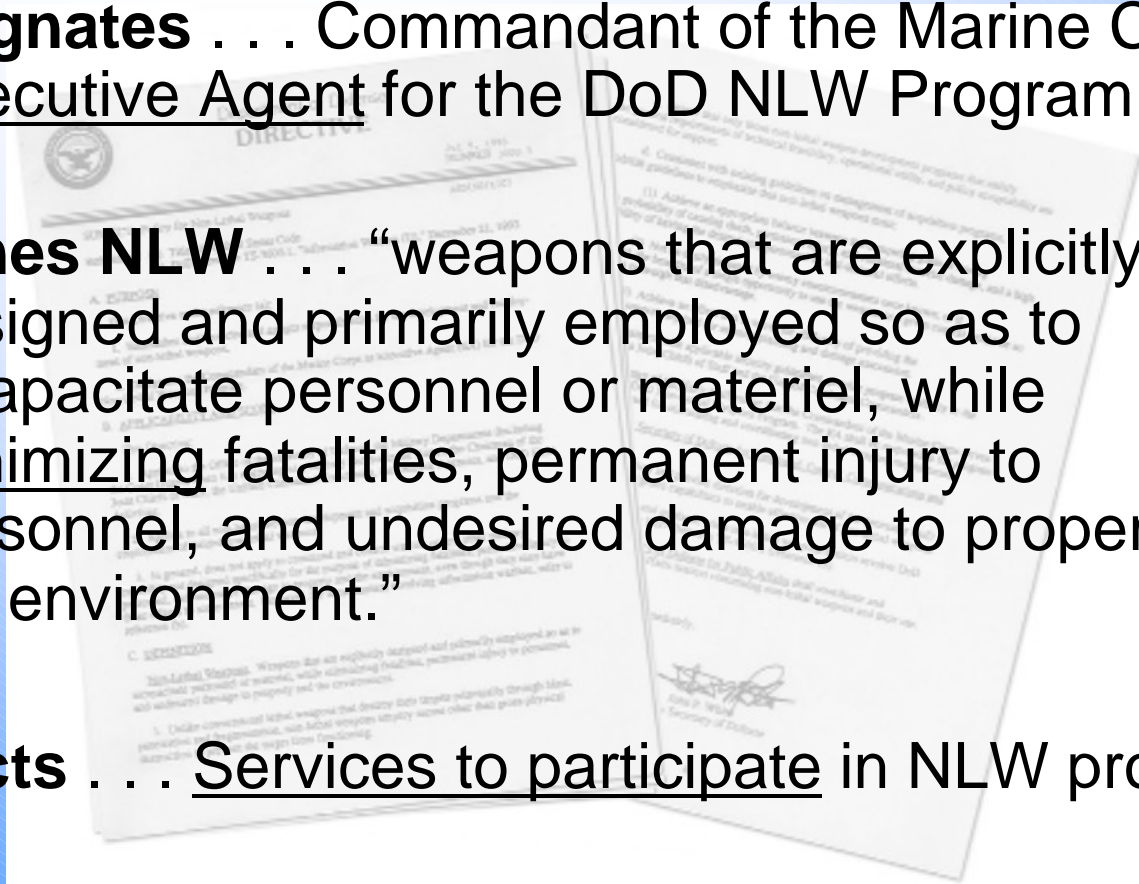
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- **DoD NLW Policy**
- **Organizations and Roles**
- **Joint Mission Area Analysis**
- **Concept Exploration Programs**
  - **Crowd Control**
  - **Area Denial to Vehicles**
- **CEP Process & Challenges**
- **Conclusion**

# Why Non-Lethal?

## DoD Directive 3000.3, 9 Jul 96 Policy for Non-lethal Weapons (NLW)

- ... **Designates** ... Commandant of the Marine Corps  
Executive Agent for the DoD NLW Program . . .
- ... **Defines NLW** ... “weapons that are explicitly  
designed and primarily employed so as to  
incapacitate personnel or materiel, while  
minimizing fatalities, permanent injury to  
personnel, and undesired damage to property and  
the environment.”
- ... **Directs** ... Services to participate in NLW program









# Army NL Organizational Structure

## COMBAT DEVELOPER

★ Army Proponent for NLW  
USAMPS

COL Treuting  
Army JCIG Principal

LTC Crockett  
DCD

CAO  
LTC Avery

PSO  
Mr. W. Barbour

## TECHNOLOGY DEVELOPER

★ TACOM-ARDEC

COL Padgett  
CCAC

Mr. J. Cline  
NLTIC Systems Manager

CPT A. Tasca  
Deputy Systems Manager

Mr. F. Hanzl  
CC CEP Proj Ldr

Mr. D. Millette  
AD-V Proj Ldr (Previous)

## MATERIEL DEVELOPER

★ MDA (PEO-AMMO)

COL Irish  
PM MCD/NL

Mr. J. Pelino  
NL Sr Project Manager

Ms. S. Salazar  
NLCS Project Manager



# DoD Joint NLW

## Core Capabilities & Functional Areas

### - Joint Mission Area Analysis (JMAA) -

DOD 3000.3: Policy for Non-Lethal Weapons - “NL Weapons are explicitly designed and primarily employed so as to incapacitate personnel or materiel, while minimizing fatalities, permanent injury to personnel, and undesired damage to property and the environment.”



#### Counter-Personnel\*

- **Crowd Control**
- **Incapacitate Ind'l Personnel**
- **Denial of Area to Personnel**
- **Clear Facilities & Structure of Personnel**



#### Counter-Materiel\*

- **Area Denial to Vehicles**
- **Disable/Neutralize Equipment**



\* Functional Areas / Tasks  
Prioritized by all CINCs at  
1996 DoD NLW User's Conference;  
Joint Concept for NLW's  
&  
Per JMAA Jan 2000

# Crowd Control CEP



## USER PAYOFF -Primary Mission Tasks

- Contain or stop the crowd from advancing
- Disperse a crowd between 50-1000 meters
- Direct the crowd movement
- Isolate specific individual(s) within a crowd
- Separate Belligerents
- Disperse a crowd within 0-50 meters

## DESCRIPTION

- Joint NLWP formal Phase A CEP assigned to Army as lead
- Identify, analyze and evaluate alternative concepts that satisfy selected NL Crowd Control mission tasks

## MILESTONES

- |                        |               |                                     |
|------------------------|---------------|-------------------------------------|
| • MNS approved         | Oct 96 (Army) | <input checked="" type="checkbox"/> |
|                        | Mar 96 (USMC) | <input checked="" type="checkbox"/> |
| • Joint MNS (draft)    | pending       | <input type="checkbox"/>            |
| • Milestone A          | 2QFY01        | <input checked="" type="checkbox"/> |
| • Phase A Decision Rev | 3QFY03        | <input type="checkbox"/>            |



# Crowd Control CEP Program Description

---

**Program Description:** Identify, develop, and evaluate alternative system concepts that satisfy the jointly scoped mission tasks of the Crowd Control NL functional area.

## **Primary Mission Tasks:**

- Contain or stop the crowd from advancing
- Disperse a crowd between 50-1000 meters
- Direct the crowd movement
- Isolate specific individual(s) within a crowd
- Separate Belligerents
- Disperse a crowd within 0-50 meters



## **Secondary Mission Tasks:**

- Resolve “Human Shields” situations
- Channelize or isolate the crowd
- Tag/Mark the crowd from the ground



# Crowd Control CEP

## Operational Context & Capabilities

### CROWD CHARACTERISTICS

- Crowd Size
- Crowd Motivation
- Crowd Composition
- Crowd Concentration & Area
- Crowd's Armament

### OPERATIONAL CAPABILITIES

- Effectiveness
- Length of Effectiveness
- Speed of Effectiveness
- Weight
- Range
- Accuracy



# CC CEP Operational Context

## Crowd Characteristics

---

- **Crowd Size:** A group of 30 to 1000 people
- **Crowd Motivation:** Motivation is considered more significant than numerical size of a group.

### Four levels of crowd motivation to be considered:

- **Casual** - No common bond within the crowd, requires space and people (i.e. outdoor mall)
  - **Sighting** - Similar to Casual Crowd, both have the two elements of people and space, requires a third element- an event. (i.e. fire, crime, accident, concert, ball game)
  - **Agitated** - Elements of a Sighting Crowd, but includes the element of a heightened state of emotion.
  - **Mob** - Has the elements of people, space, event, emotions, and physical activity, but is characterized by hostility and aggression.
- **Crowd Composition:** A representative figure for the composition of a crowd is 70% male/30% female with all age groups, to include minors reflected.

# CC CEP Operational Context

## Crowd Characteristics (cont)

---

- **Crowd Concentration & Area:** The concentration or number of people per square meter ( $\text{m}^2$ ).

Three categories designed on the basis of the density of people per square meter:

- |                       |                           |
|-----------------------|---------------------------|
| - <b>Light Crowd</b>  | 1 person per square meter |
| - <b>Medium Crowd</b> | 3 people per square meter |
| - <b>Heavy Crowd</b>  | 4 people per square meter |

The area can be as small as  $25 \text{ m}^2$  for a heavy crowd of 100 people to as large as  $1000 \text{ m}^2$  for a light crowd of 1000 people.

- **Crowd's Armament:** Crowds will be armed with objects readily at hand including metal shields (garbage can lids) for defense and rocks, pipes, bats, and molotov cocktails as offensive weapons. The presence of armed militants is a separate consideration.





# **CC CEP Operational Characteristics**

---

- **Effectiveness:**
  - Not applicable against a casual crowd.
  - Shall influence 99% of the sighting crowd.
  - Shall influence 85% of the agitated crowd.
  - Shall influence 80% of the mob crowd.
- **Length of Effectiveness:** Minimum effectiveness is not less than 10 minutes, but desired effectiveness of 12 minutes or longer. Injuries requiring prolonged or extensive medical treatment must be excluded.
- **Speed of Effectiveness:** Preference is for near instantaneous effect and minimizing onset time is critical. For guidance an interim goal is three (3) minutes.

# CC CEP Operational Characteristics (cont)

---

- **Weight:** For systems, minimizing weight must be considered with a goal of:
  - not heavier than 35 pounds for man portable items
  - no more than 1100 pounds for HMMWV
  - no more than 2500 pounds for HMMWV trailer

- **Range:** Desired effective range is:
  - 0-100 meters for point engagement
  - 50-1000 meters for area targets

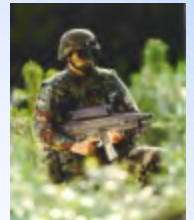


- **Accuracy:**
  - For a point engagement capability, selected target must be engaged at ranges up to 100 meters with 95% or greater probability of hit, excluding human factors.
  - For an area engagement capability, +/- 25 meters from point of impact is the goal if appropriate.

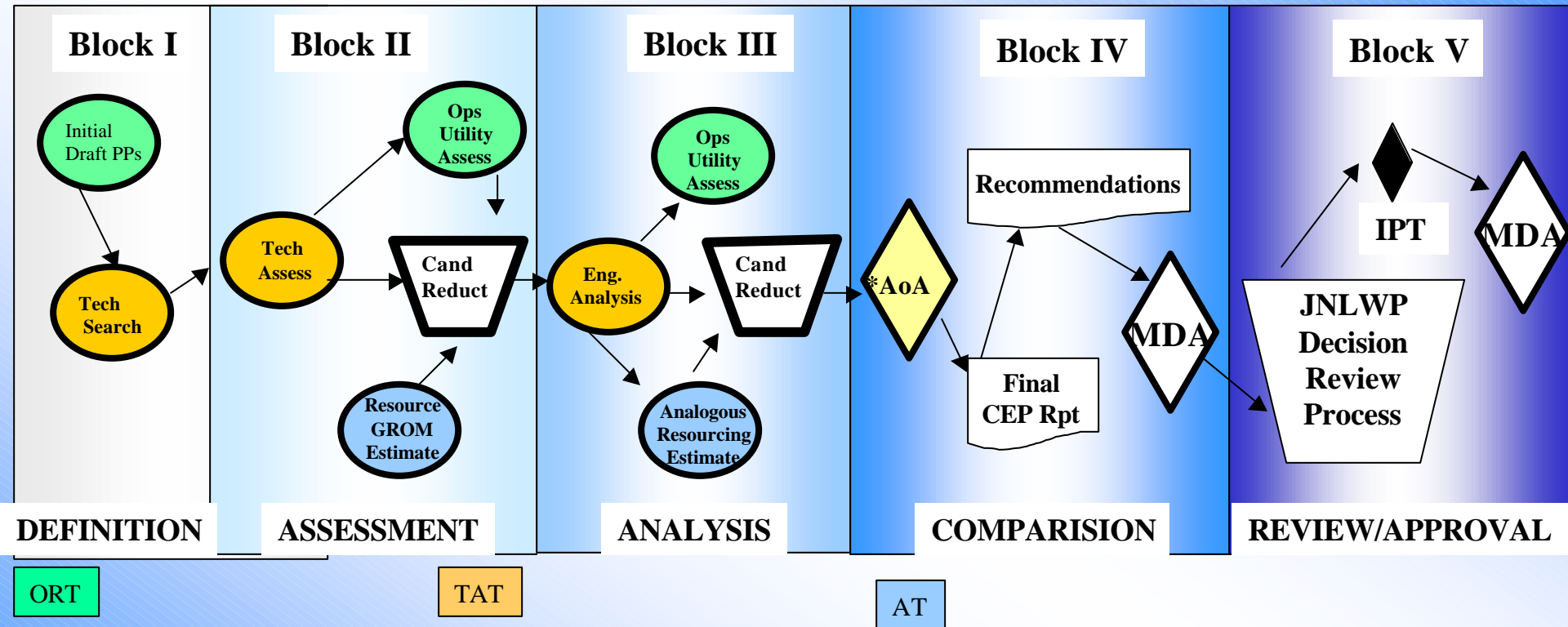


# Example CC CEP Candidate Technologies

- Barriers
- Sound
- Air Vortices
- Temperature
- Water
- Visual Dazzlers (Light, Lasers)
- Chemicals:
  - RCA Type (Malodorants, Irritants, etc.)
  - Other (Anti-Traction Materials)
- Directed Energy (Laser, Millimeter Wave)
- Electric Stun
- Enhanced Blunt Impact
- Combined Effects (Multi-Sensory, Flash/Bang, etc.)
- Legacy & Objective Force Delivery Platforms
  - M16/ M4, M203, MK19, 60 & 81mm Mortars, etc.
- Other Platform Capabilities (Robots, UAV/UGVs)



# Generic CEP Process (CC & AD-V)



**\*AoA (Analysis of Alternatives) or  
Analysis of Multiple Concepts (AoMC)**

# CEP Teams & Deliverables

## Operational Requirements Team

- Operational Concept
- Desired Performance Characteristics
- Simulation Support Plan
- Performance Parameters
- Initial Key Performance Parameters
- Scenarios/Vignettes
- Measures of Effectiveness (MOE)
- Operational Utility Analysis
- Threat Assessment Report
- Draft Operational Requirements Document

## Technical Architecture Team

- BAA & MS A package
- Measures of Performance (MOPs)
- M&S Study Plan - Feeder Data
- Preliminary Human Effects Assessment
- Technical Risk Identification & Mitigation
- Technology Search, assessment and analysis of candidate systems

## Recommendations

Acq #1-n

CAD

CEP (sys-spec)

CEP (non sys-spec)

S&T Investment

## Acquisition Team

- Resource Estimation Reports
- Draft Acquisition Program Baseline
- Draft Acquisition Strategy Report
- Life Cycle Cost Estimates
- Prelim Test and Evaluation Master Plan
- Exit Criteria
- Preliminary Legal Review
- Programmatic Risk Management Plan
- Integrated Program Summary

# Crowd Control CEP Challenges

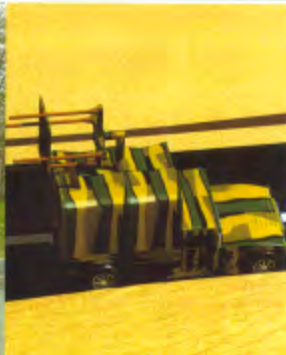
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- **Human Effects / Effectiveness**
  - Quantification & Validation of Target Effects on Humans of Candidate Technologies
    - Population Variation (Degree of Susceptibility)
  - Measurement & Determination of Operational Effectiveness.
- **Modeling & Simulation of Crowd Behavior / Response to Crowd Control Concept Systems**
  - Motivation Levels
  - Crowd Dynamics
- **Scenario Dependency**





# Area Denial-Vehicles CEP



## USER PAYOFF

## Primary Mission Tasks

- Deny an area to land vehicles
- Stop a vehicle-urban/suburban environment
- Channelize vehicles
- Stop a vehicle-open/rural environment

## DESCRIPTION

- Joint NLWP formal Phase A CEP assigned to Army as lead
- Identify, demonstrate, and evaluate alternative concepts that satisfy NL Area Denial to Vehicles mission tasks
- Not limited to pre-emplaced systems

## MILESTONES

- |                        |         |                                     |
|------------------------|---------|-------------------------------------|
| • MNS approval         | FY96    | <input checked="" type="checkbox"/> |
| • Joint MNS (draft)    | pending |                                     |
| • Milestone A          | 2Q FY01 | <input checked="" type="checkbox"/> |
| • Phase A Decision Rev | 3QFY03  | <input type="checkbox"/>            |



# **Area Denial to Vehicles CEP**

## **Desired Operational Capability Parameters**

- Area (Perimeter Distance, 5km Max)
- Target
  - Combat Vehicles
  - Large Vehicles (Up to 80,000 lbs)
  - Small Vehicles (< 8,000 lbs)
- Effectiveness
  - Breach Prevention with 90% probability up to 20 minute delay
- Speed & Duration of Effectiveness
- Sensory System
  - Alert Operators to Breach
- Operational Range
  - 0-300 meters (T)
- Emplacement Time
- Cyclic Engagement Rate
- System Weight
  - Man Portable (<35 lbs)
  - HMMWV Mtd (<1100 lb)
  - HMMWV Towed (< 2500 lb)
- Logistic Considerations
- Environmental Considerations
  - No lasting effects from use
- Reversibility of Effect(s)
- Avoidance of Collateral Damage & Fratricide
- Resistance to Countermeasures

# Example Non-Lethal AD-V Candidate Technologies



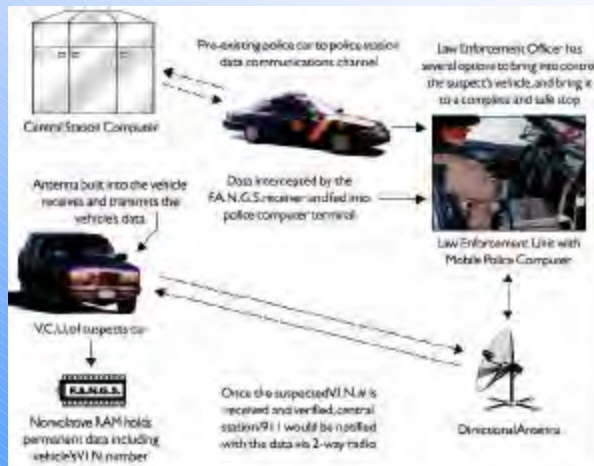
**Caltrops**



**M1, Portable Vehicle Arresting Barrier, (PVAB)**



**Standoff Radio Frequency Ground Vehicle Stopper (ARL)**



**Example “Cooperative System”  
-Frequency Activated Neutralizing  
Generator System (FANGS)**

**Anti-Traction Material (USMC)**



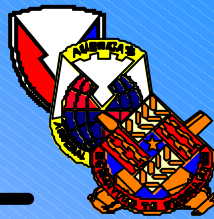
**Fire  
Support  
Standoff  
Delivery  
Platform  
(w/ NL AD-V Payload)**



**Advanced Tactical Laser**

# AD-V CEP Challenges

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- **Human Effects / Effectiveness**

- Quantification & Validation of Target Effects on Humans resulting from use of potential Candidate Technologies
- Measurement & Determination of Effectiveness

- **Scenario Dependency**

- Class of Vehicle (Military / Commercial), Speed & Weight of Vehicle, Vehicle Prime Mover (Diesel, Combustion, Electric, Hybrid)
- Terrain (Sand, Asphalt, Concrete, Icy Road, Urban vs. Rural Env't))
- Collateral Damage (Uncontrolled Stops, Vehicle Fratricide, Self-Contamination)

- **Apparent Technology Limitations to Address Apparent Void for “Ideal” Operational Capability:**

Portable, Hand-Held, Vehicle Stopper with Standoff Capability to Instantaneously Stop All Moving Vehicles with Reversible, NL Effects without any Collateral Damage or Environmental Degradation.



# Summary

---

- Numerous Urgent Fieldings have led to 1<sup>st</sup> Generation Crowd Control & Area Denial to Vehicles materiel items currently, or soon to be, in the Service's Non-Lethal Capabilities Sets (*e.g., Blunt Impact Munitions & Caltrops*)
- The JROC Approved DoD NLW JMAA conducted by the JNLWP is basis for the formal Concept Exploration Programs
- Purpose of CC & AD-V CEP's is determination of viable 2<sup>nd</sup> & 3<sup>rd</sup> generation NL Capabilities for Joint Service use
- CEP's are following JNLWD CEP Guide (Update in Process)
  - All CEP's affected by DoD 5000.2 Rewrite
- CEP's can result in any number of recommendations:
  - S&T investment is required;
  - Component Advanced Development is needed;
  - Mature technology with improved capability identified , Acquisition program(s) are recommended

# Back-Up Slide



# CEP Decision Support Analysis (DSA) Process

---

- Decision Support and Analysis (DSA) process is being used in support of the NLW CC & AD-V Analysis of Alternatives (AoA) / Analysis of Multiple Concepts (AoMC)
  - First, a basic decision model or tree is developed;
  - Measures of Performance (MOP) & MOEs are developed by the Users.
- Models & Criteria definitions are established & agreed. A pair wise comparison of the criteria with respect to user “requirements” is conducted.
- The pair wise comparison is the heart of the DSA as it allows each service to define key issues, through open floor discussions, and place greater weight on the most important Measures of Performance and Measures of Effectiveness.
- All Information feeds into Analysis of Multiple Concepts. AoA/AoMC is not stand-alone at this early stage of CE since Performance Data is typically not sufficiently quantified , nor validated.



# U.S. COAST GUARD

## CURRENT & DESIRED COAST GUARD LETHAL & NONLETHAL CAPABILITIES





# HOMELAND SECURITY ARMAMENT

- **HARBOR ENVIRONMENT**
  - **AUTOMATIC FIRE**
  - **ANTI-PERSONNEL WEAPON**
  - **USED FROM CG SMALL BOATS**
  - **SOME ANTI-MATERIEL CAPABILITY**
  - **250-400 YD EFFECTIVE RANGE**
  - **MINIMIZE COLLATERAL DAMAGE**





# CURRENT NON-LETHAL CAPABILITIES

- **CG NON-LETHAL CAPABILITIES AUTHORIZED FOR:**
  - COUNTERDRUG OPS
  - ALIEN MIGRANT INTERDICTION
- **CURRENT CAPABILITIES**
  - ANTI-MATERIEL
    - .50CAL PRECISION TARGETING ROUND
    - MANUALLY DEPLOYED ENTANGLEMENT NET
  - ANTI-PERSONNEL
    - 12 GAUGE BLUNT TRAMA





# FUTURE NON-LETHAL CAPABILITIES

- **NEAR TERM**
  - **ANTIMATERIEL**
    - **AUTOMATIC SURFACE AND AERIAL DEPLOYMENT OF ENTANGLEMENT NETS**
    - **STATIC BARRIER ENTANGLEMENT NET**
    - **12GA ENGINE DISABLER ROUNDS**
    - **SPEED INHIBITORS**
  - **ANTIPERSONNEL**
    - **12GA OC ROUND**







# DESIRED CAPABILITIES

- **LONGER-RANGED  
ANTIPERSONNEL NLWs**
- **LONGER-RANGED NLWs  
TO STOP PLANING HULL  
CRAFT**
- **ANTIPERSONNEL NLWs  
CAPABLE OF ACCURATE  
DELIVERY FROM A  
HELICOPTER**





# DESIRED CAPABILITIES

---

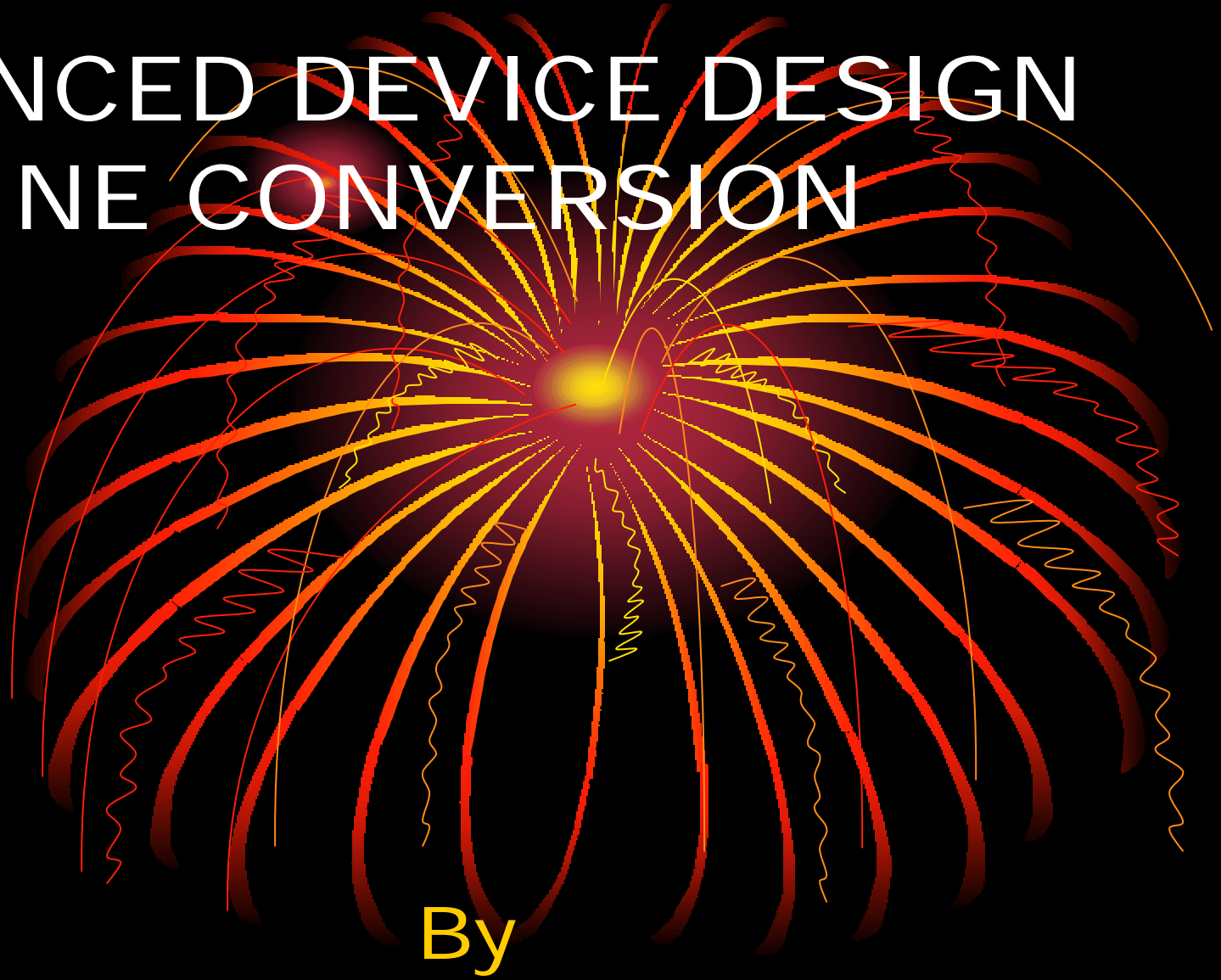
- MORE EFFECTIVE CROWD CONTROL NLWs
- NLW AGAINST PEOPLE IN THE WATER
- NLWs AGAINST JETSKIS
- NLWs TO STOP LARGE DISPLACEMENT HULL SHIPS





**The Future – 62 Lbs (w/62 Rounds)**

# ADVANCED DEVICE DESIGN CARBINE CONVERSION



By  
Charles Cutshaw

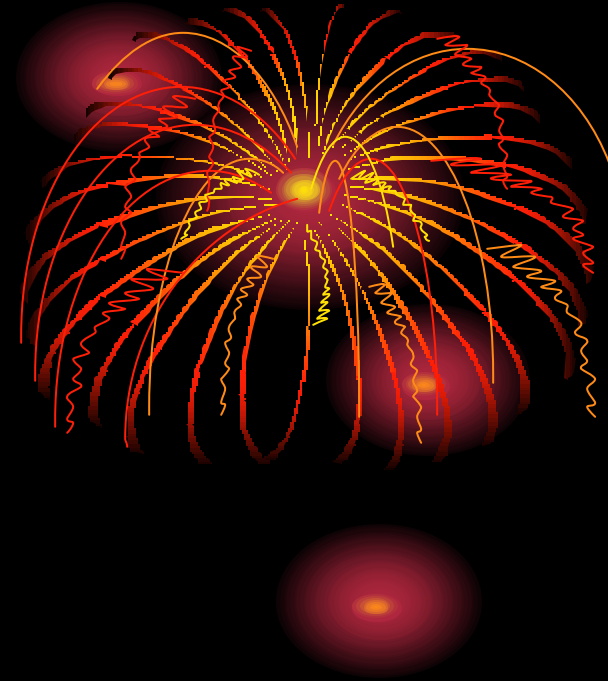
# ADD CARBINE CONVERSION

- Free float barrel
- New operating system
- Reduced cyclic rate
- Enhanced heat dissipation
- Improved muzzle brake
- Improved reliability
- Enhanced Maintainability





# ADD HANDGUARD RAIL SYSTEM



- Mounts to MIL-STD-1913 upper
- Full-length MIL-STD-1913 top rail
- MIL-STD-1913 side & bottom rails
- Free-Floats barrel

# NEW OPERATING SYSTEM



- M14 Based gas tube & piston
- SKS-type operating rod
- Adjustable gas port
- Bolt carrier counter weights
- Hydraulic buffer

# OPERATING SYSTEM ADVANTAGES



- Felt recoil reduced
- Gas rings eliminated
- Muzzle climb virtually eliminated
- Receiver fouling eliminated
- Cyclic rate reduced to 600-650 rounds/minute
- Controllability greatly enhanced

# HEAT DISSIPATION



- Aluminum heat sink
- Airflow Enhanced cooling
- Passed non-stop 450 round full auto torture test
  - 30 rd bursts
  - Hand guard only warm
  - No effect on optics or accessories
  - Barrel remained within specs

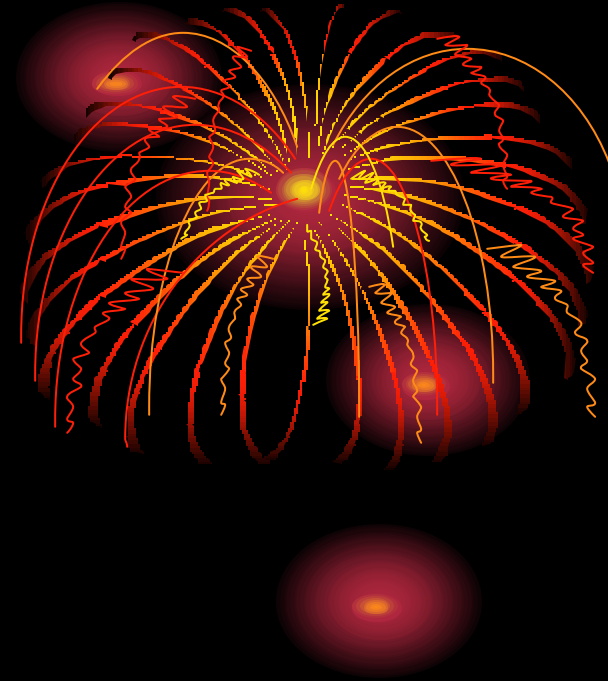
# MUZZLE BRAKE



- Balanced pressure design
- No effect on accuracy
- Enhanced Flash suppression
- Standard Threads for existing muzzle devices



# MAINTAINABILITY RELIABILITY ENHANCEMENTS



- Gas tube eliminated
- Gas rings eliminated
- Barrel life improved No receiver fouling or carbon buildup
- Barrel life improved

# OTHER ENHANCEMENTS



- Accuracy speaks fire control
  - 4.0 lb semi-auto pull
  - 6.0 lb full auto pull
  - Clean "break"
  - No creep
- AMBI-CATCH magazine release

# *THE HORUS VISION SIGHTING SYSTEM*



Presented by  
Charles Q. Cutshaw


# *SHOOTING with the HORUS SYSTEM*



To shoot at long range, the rifleman must know:

- Distance to the target
- Ballistics of the cartridge in the rifle
- “Come-ups,” to compensate for bullet drop
- Windage Corrections
- Correction for uphill or downhill shooting

# *Horus - Works with any caliber*

- 
- Bullet drop compensation is computer calculated for specific caliber & load.
  - Functions from 5.56 mm to 50 BMG



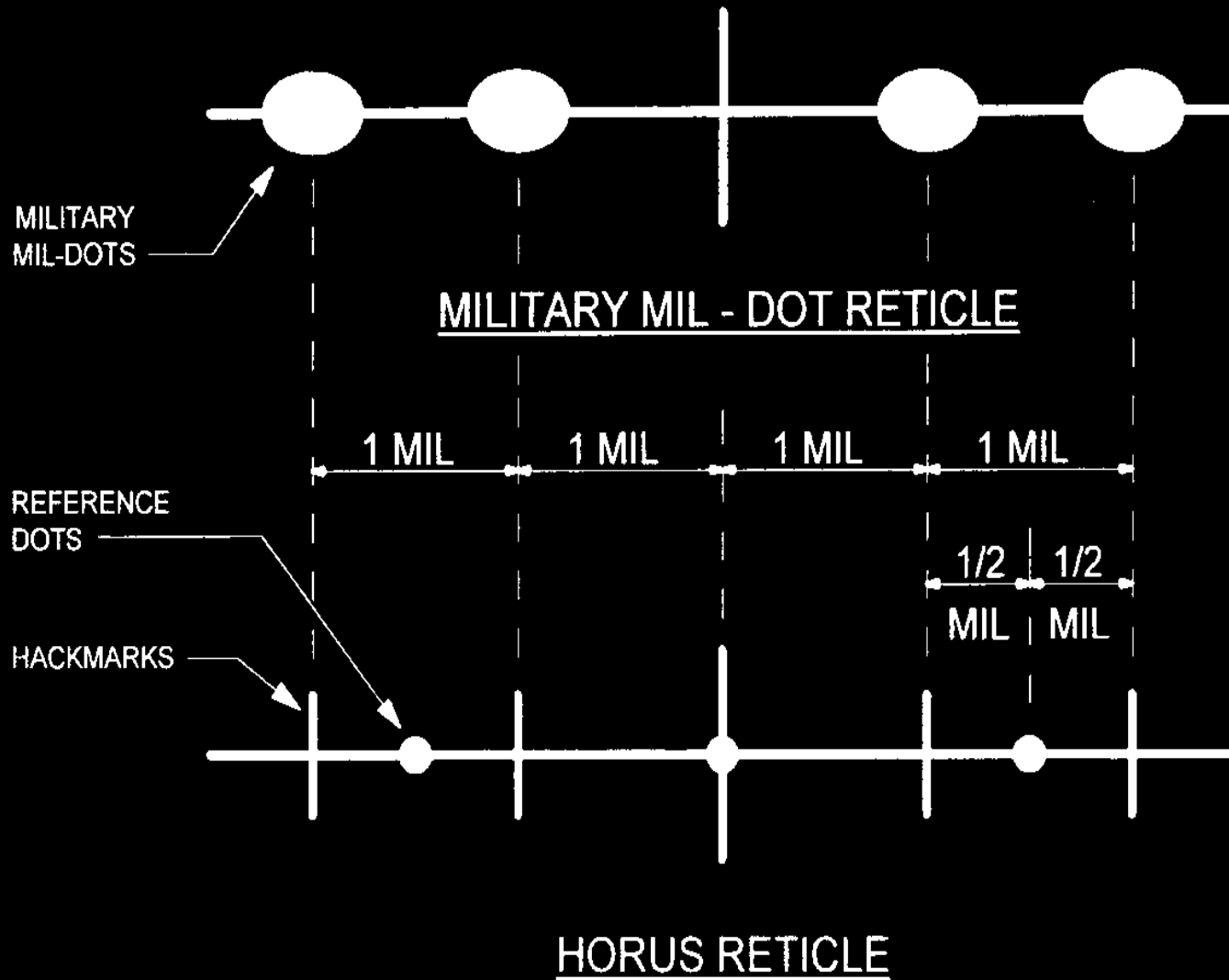
# *HORUS VISION SIGHTING SYSTEM*

## *– 21<sup>st</sup> Century*



- The Horus Reticle brings current MIL-DOTS into the 21<sup>st</sup> Century.
- Because Horus is in 1<sup>st</sup> focal plane, it works at any magnification.

# *HORUS RETICLE MIL DOTS*




# *Horus Vision Features*

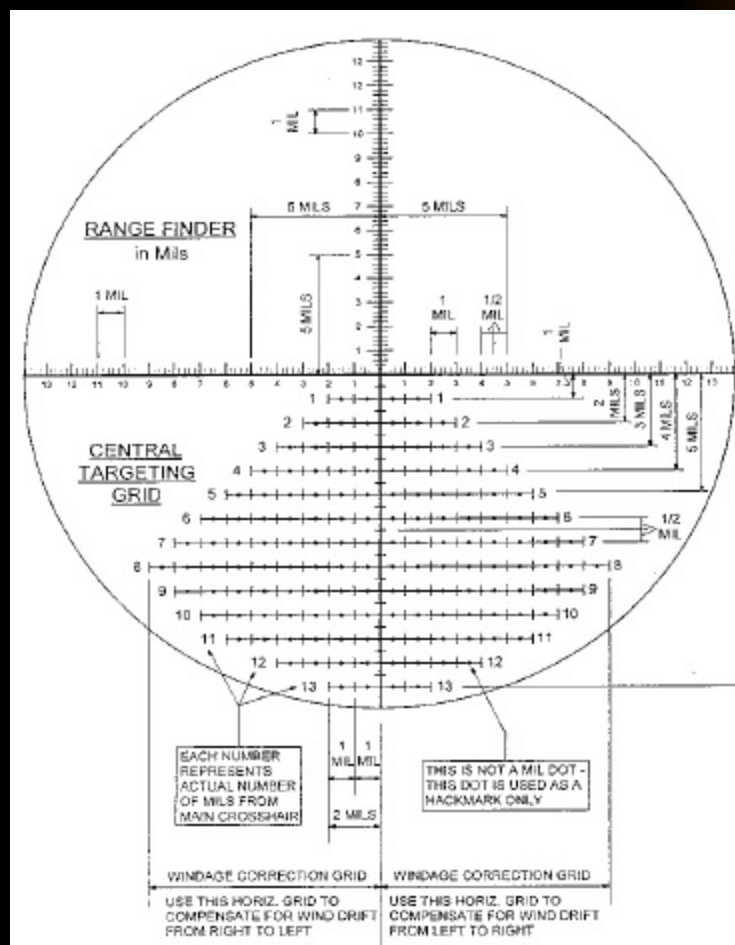


- Mil-Dot Based
- Much more precise than current Mil-Dots
- Faster ranging and targeting than current Mil-Dots
- Dialed in “come-ups” eliminated
- Training time reduced
- Ranging possible @ any magnification

# *The Horus Reticle*

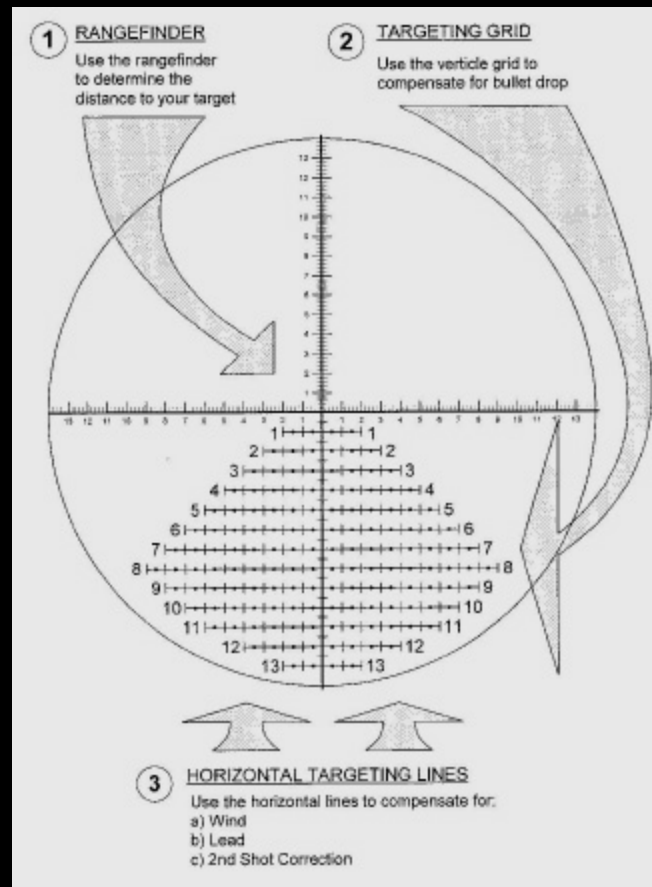
- 
- The reticle is composed of two parts:
    - The Range Finder
    - The Targeting Grid
  - Both calibrated in USMC MILS
  - Range finder accurately measures to .10 of a MIL
  - Central targeting grid provides for elevation adjustment.
  - Wind deflection allows for 20-30 mph full value wind correction
  - Lead on moving targets
  - Second shot correction.

# SPECIFICATIONS

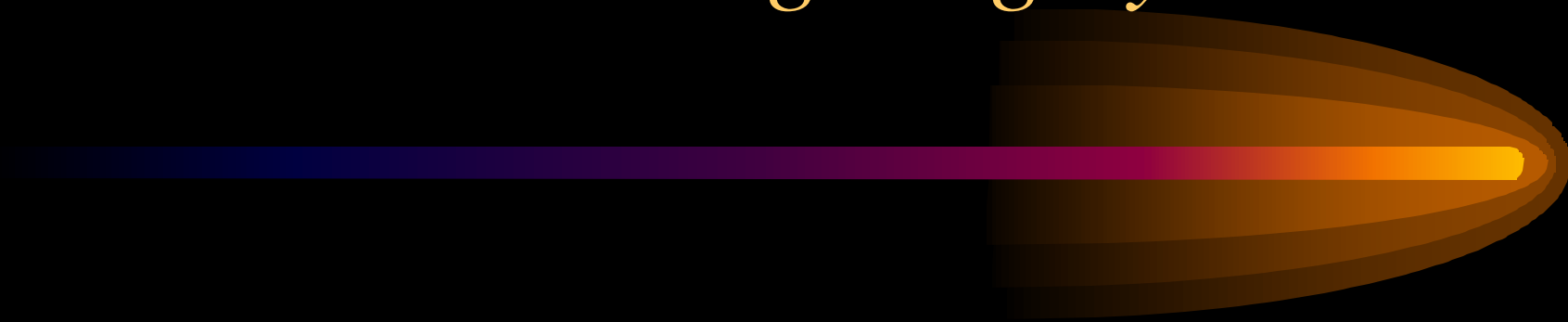




# HORUS TARGETING



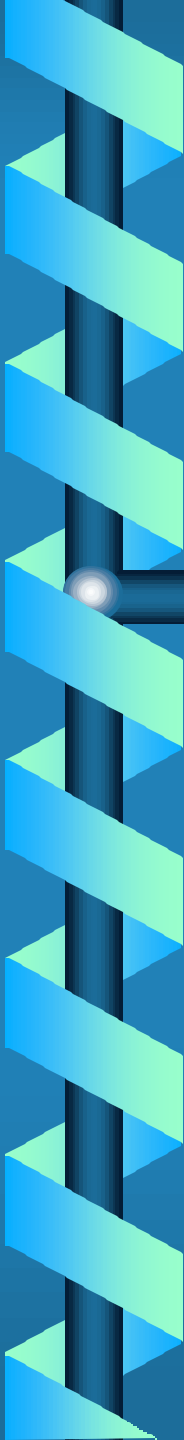
# *Horus – Total Sighting System*

- 
- Scope & Mounts
  - Handheld computer
  - PC Software
  - Pocket metrological station

# *Horus Vision Mission Essential Components*



- Scope & Mounts
- Range Card - “Cheat Sheet”



# Top-Gun Technologies, Inc. Firearm Finishing Processes

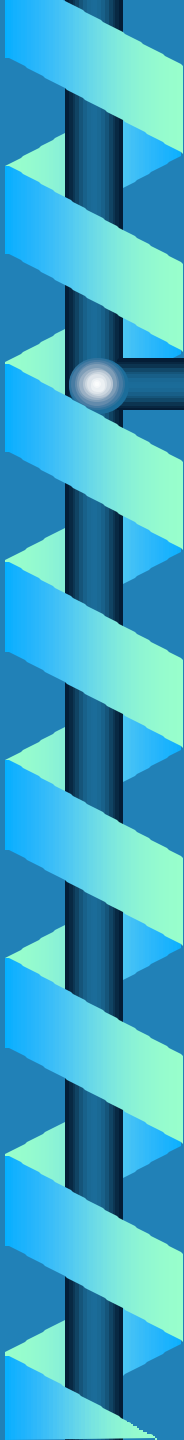
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Presented by  
Ollie Daw, COO

# Top-Gun: Metal Finish Process Not a Coating







# Problems with Current Processes

- Surface corrosion on Parkerized and Black Oxide
- Non-uniform color
- Delamination of polymer coatings (Teflon)
- Delamination of Plated Surfaces
- Uneven deposition of hard chrome plate



# Current Problems Con't

---

- Stainless steel suffers from corrosion
- Cost (Stainless Steel, Titanium)
- EPA hazards (chrome plating processes)
- Plating process reduces material strength.

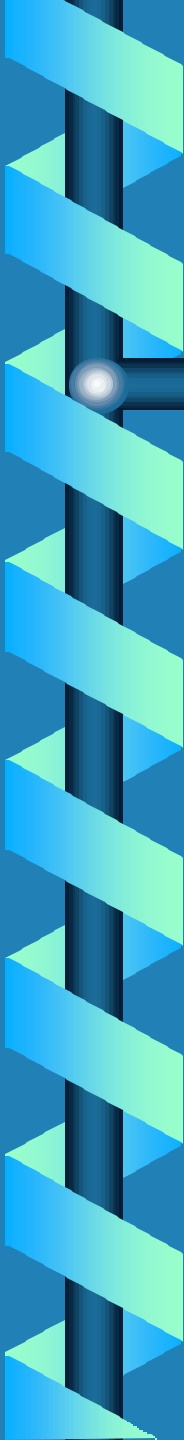
# Contrast in Effectiveness





# Stealth-Tech Advanced Gun Finish Process

- Corrosion protection to 100% of metal surfaces including the barrel bore.
- All of the advantages of the popular process without the typical problems
- Reduces wear – dry film lubricants impregnated into the metal including the bore



# Stealth-Tech Advanced Finish Process (Con't)

---

- More durable and reliable than Teflon coatings, Parkerizing or black oxide
- Applied to all metal surfaces, including carbon steel, aluminum and stainless steel.



# Alabama Marine Police Top-Gun Exclusively



- Hostile environment
- Maintenance reduced: cost & time
- Extended service life of equipment



# Ultra-Tech Advanced Gun Finish Process

- All of the advantages of Stealth-Tech process plus improved corrosion resistance and wear resistance
- Parts can be made to size then processed without allowance for plating thickness or excessive nitride growth



# Ultra-Tech Advanced Process Con't

---

- Normalizes and stress relieves barrels providing consistent shot grouping
- Uniform surface, not possible with hard chrome plating
- Will not de-laminate as the metal is transformed rather than plated



# Ultra-Tech Advanced Process Con't

- Better corrosion resistance from chrome moly steel than possible with stainless steel –increases fatigue and tensile strength
- Superior wear resistance & reduced friction (Rockwell Hardness C58 – C61)



# Precision Airdrop Infantry Resupply

## Key Emerging Technology Area for Objective Force Sustainment

Smart Airdrop from High  
Altitude and when required,  
significantly offset from the  
Drop Zone

- Pinpoint, Just-in-Time Airdrop
- Eliminate Aircraft Vulnerability
- Eliminate Drop Zone Detectability

**Edward Doucette**  
**Director, Airdrop/Aerial Delivery Directorate**  
**U.S. Army Natick Soldier Center**





# What Is Precision Airdrop?



- **Family of Parachutes and Control Systems (based on weight)**
- **Common Navigation System**

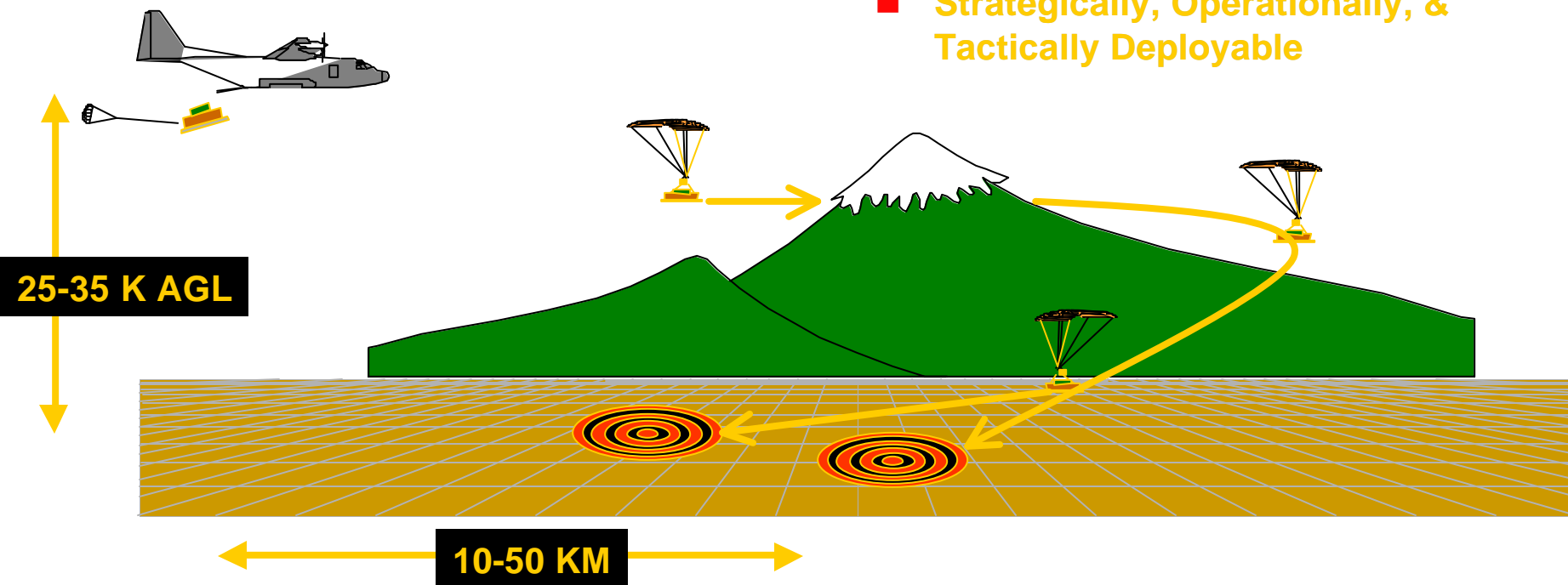
## **RIGGED LOAD**

- **Standard Bundle**
- **Standard Pallet**
- **New technology?**



# Benefits of Precision Airdrop

- **Increased USAF Survivability**
- **High Altitude Deployment 25-35 K FT**
- **Offset/Standoff 15-50 KM**
- **Autonomous Operation**
- **Compensates for CARP Errors**
- **Rapid Resupply Over Strategic Distances**
- **Increased Accuracy (25-100 M CEP)**
- **Multiple Loads/Multiple Destinations**
- **Major Sustainment Enabler and Footprint Reducer**
- **Strategically, Operationally, & Tactically Deployable**





# Future Precision Aerial Resupply Family of Systems



- Precision Gliding Airdrop
- High Altitude, Precision Container Delivery Airdrop
- Powered, Extended Offset Precision



**Objective Force Aerial Resupply**

**Autonomous, Remote Delivery of  
Sensors, Munitions & Equipment  
to Multiple Drop Sites**



# Powered Parafoil Resupply

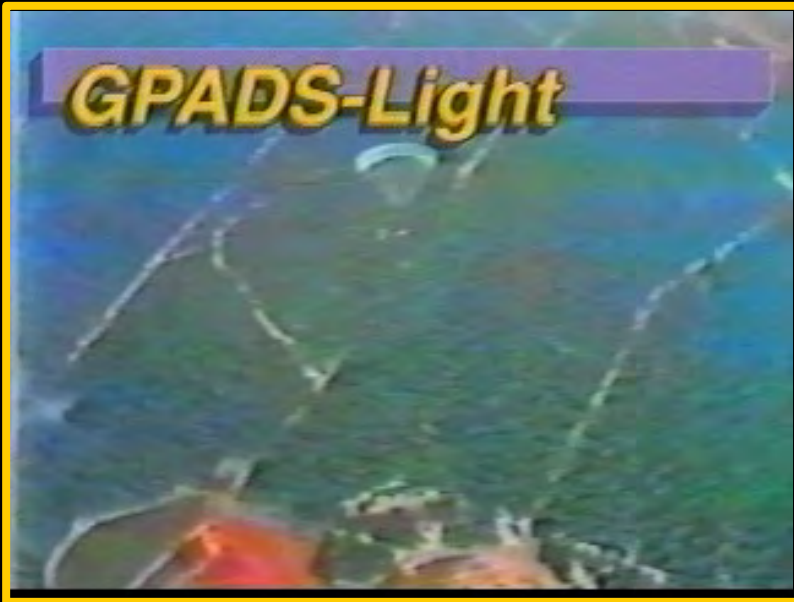
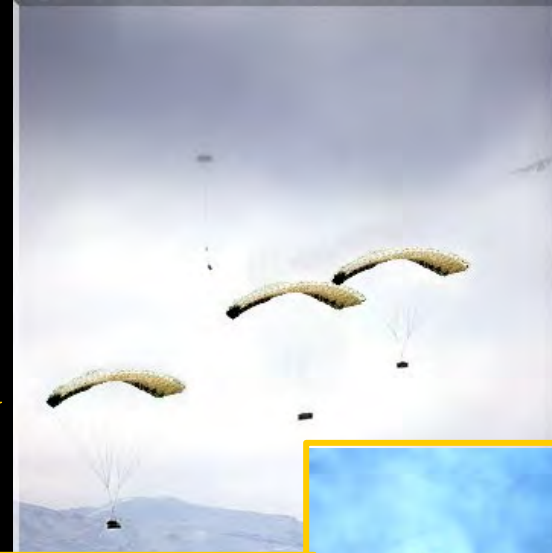




# Technology Focus Area

## Aerodynamic Decelerators

- Gliding parachutes
  - Parafoils
  - Paragliders
- Deployable semi-rigid and rigid wings



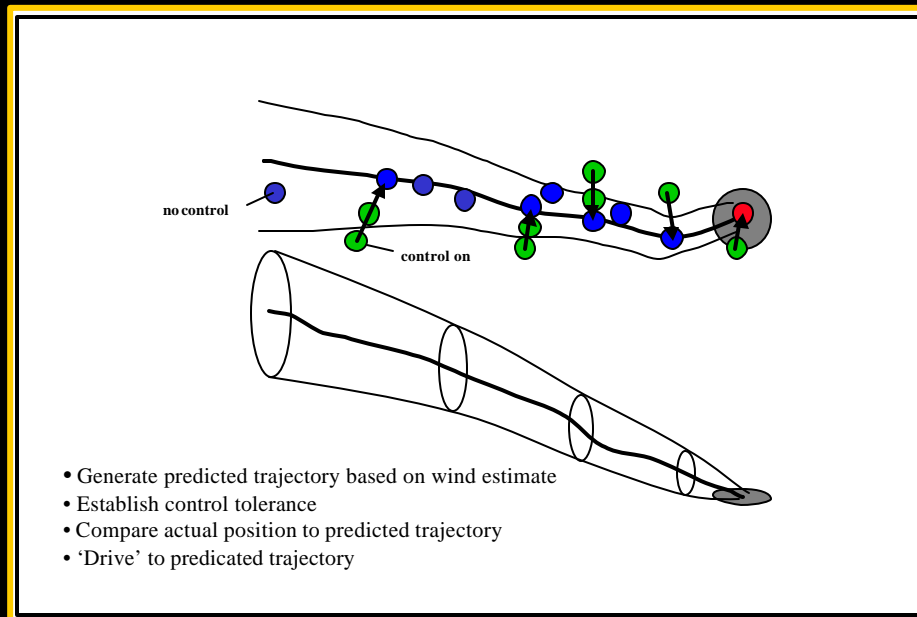




# Technology Focus Area

## Sensors & Actuators

- Guidance, Navigation and Control
- Ground proximity/height sensing
- Weather/wind sensing
- Autonomous steering





# Technology Focus Area

## Powered Precision System Integration





# Technology Focus Area Airdrop System Modeling



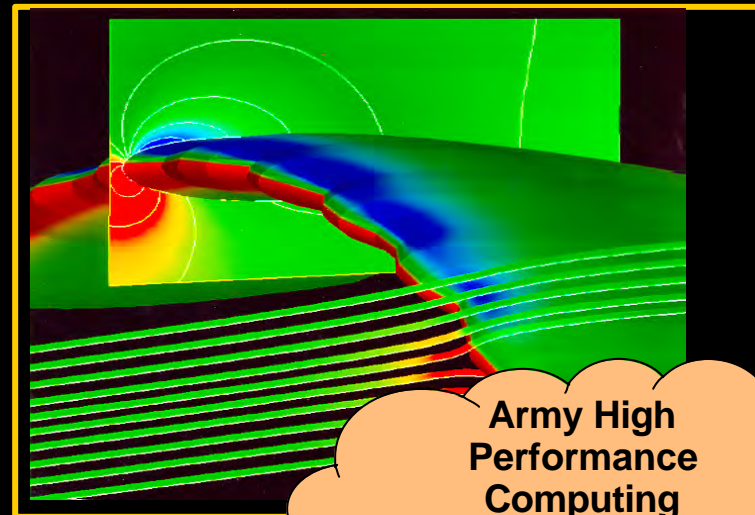
## Army's Airdrop Modeling Vision:

Meet challenge of Airborne Virtual Proving Ground

- Analytical prediction of parachute performance.
- Optimize parachute designs for higher performance and reduced life cycle cost.
- Decrease RDTE costs and time to fielding new airdrop systems.
- Develop high fidelity parachute computer models for design trade-offs and virtual testing /experimentation.
- Wind/weather prediction (leveraged)

## Technical Approach:

- Numerically predict parachute opening and steady state characteristics, Model Fluid-Structure Interaction
- Numerically Couple Modified Computational Fluid Dynamics (CFD) and Structural Dynamics Codes
- Leveraging of outside organizations (Rice U, UCONN, NASA-JSC, AHPCRC, ARO,, ARL,)



Army High  
Performance  
Computing  
Grand Challenge  
Project

Parachute Structural Dynamics



# FCS Precision Resupply Animation





# Leaflet Delivery Animation





# Precision Airdrop Infantry Resupply

## **TODAY**

- 2200 Lb Payload Capacity Gliding Offset Systems
- 600 Lbs Powered Parafoil

## **FY08**

- 10K Lbs Gliding Offset System
- 2K-10K Lbs Low Cost, High Altitude Precision



# ***POCKET LASER RANGEFINDER UPDATE***

2002 International Infantry & Small Arms Symposium

May 16, 2002

William Dunnill

Jos van Seeters

Leica Technologies Inc  
703-777-3900  
bill.dunnill@lti.leica.com



# Outline

---

- Pocket Laser Rangefinder (PLRF)
- Viper/Vector IV
- Vector 21
- Vector N (Night)
- Laser Rangefinder/Digital Magnetic Compass Module

# ***Leica LRF Products Supporting Small Arms Users***

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VIPER/VECTOR

POCKET LRF

LRF/DMC MODULE

# LEICA PLRF - Pocket Laser Rangefinder

---



- Pocket LRF Range > 1km
- Class 1 eye safe
- Size (4.5 x 3.7 x 1.7 inch)
- Handheld (17 oz)
- 6 x 28 Monocular
- Button operated
- Adaptation to NV
- IAW MIL-STD 810
- Submersible 66 ft
- > 5,000 shots, COTS battery

# LEICA PLRF - General Characteristics

---

## Rangefinder

- Range performance: 50 - 1000 m  
(albedo 0.1, target size 1 x 1 m, vis. 7 km)
- Measurement range: 5 - 2500 m  
(theoretical on display)
- Accuracy:  $\pm 1$  m
- Diode laser: 905 nm  
1550 nm
- Eye-safety: Class 1  
according to ANSI Z 136.1 (2000)



# ***PLRF - Status***

---

- Oct. 4, 2000: Order for two 905 nm ETU (engineering test unit)  
USN Contract N00164-01-D-0004, delivery order 0001  
(delivered April 2001)
- Jan. 20, 2001: Order for two 1550 nm ETU, delivery order 0002  
(delivered July 2001)
- Feb. 14, 2002: Order for 523 1550 nm units, delivery order 0003  
(delivery to start August 2002)



# LEICA VIPER/VECTOR IV Rangefinder Binoculars

---



- 7 x 42 Binocular Optics
- Rangefinder: 5 m to 4+ km
- Class 1 eye safe
- Gating, MOM
- Compass and Inclinator
- Displays range, bearing, elevation, FO SV (8 meas. in total) in field of view
- Digital output via RS232, PLGR interface, SLP in process
- Auto boresight with NV equipment
- Floats and is waterproof
- >3000 measurements with COTS battery
- 3.7 lbs

# ***VECTOR/VIPER: Typical Applications***

---



## **Snipers**

### **Anti-tank Weapons**

Range and elevation

First round hit

Optimal deployment



## **Scouts**

### **Forward Observers**

### **Mortar Fire Controllers**

### **Engineers**

Reconnaissance

Target acquisition

Rapid surveying

Digital data capture

Gap measurement







UNCLASSIFIED



*Army Space and Missile Defense Command*

# **Low Earth Orbit Position and Reporting Device (LEOPARD)**





UNCLASSIFIED

*Army Space and Missile Defense Command*



## **Assault Pack Capabilities**

### Viper Laser Range Finder

- Azimuth, Elevation & Distance
- 4.5km range
- +/- 1m accuracy

### Palmtop

- GPS, Comms, Viper Interface
- Standard Mil Reporting Formats
- Common Operational Picture



### Mobile Satellite Service Handset (Iridium)

- Voice and Data Capability
- 2400bps transmission rate
- Worldwide over-the-horizon coverage

### PLGR II

- Provides 10 Digit Location
- Provides enemy location using the vipers

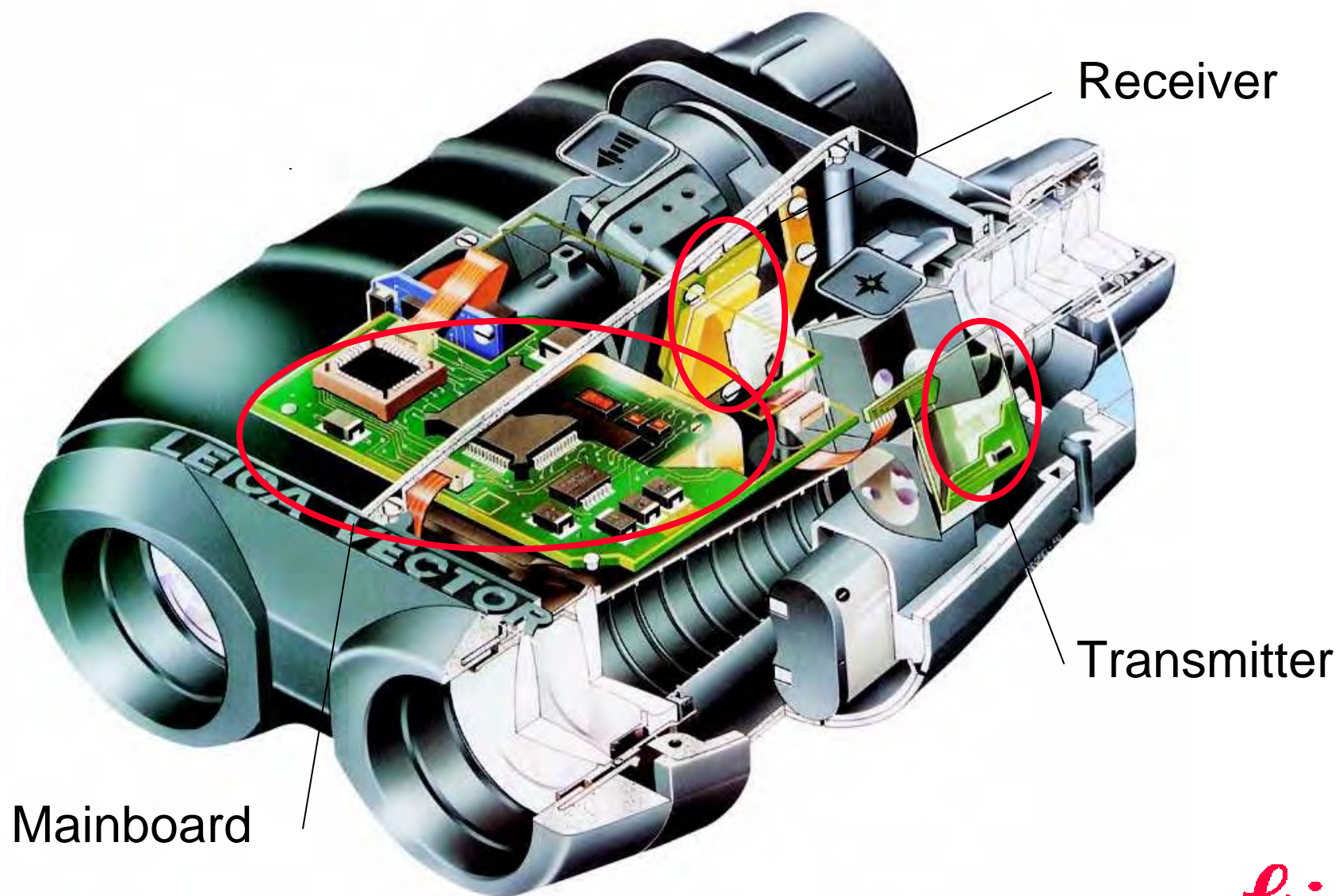
UNCLASSIFIED

*"Secure the High Ground"*



# Modifications for the VECTOR 21

---



## ***Range Comparison, at Visibility of 10 km***

---

Target, Albedo/Size	VIPER*	VECTOR 21*	Melios**	
DPST 0.5/ 0.5m	1.5 km	2.8 km	2.8 km	
NATO 0.2/ 2.3m	2.5 km	5.6 km	5.5 km	
Tree 0.23/ 5m	4.0 km	7.8 km	7.6 km	
House 0.35/10m	5.5 km	10.6 km	(10.0 km)	

\*verified with field measurements

\*\*according to data sheet



# ***Vector 21 Range Measurements in Meters***

---

Extended targets:

- 12,000, maximum
- 11,900, Mt. Scott, Ft. Sill (25 Oct 01); white house (Switzerland)
- >8,000, trees
- >7,000, slope with grass
- >4,000, slope with snow

NATO targets:

- 5,200, (2.3 x 2.3 m, 30% reflectivity; 2.3 x 4.6m, 20% reflectivity)\*
- 8,100, tank
- 1,000, smoke test (could not see target) Ft. A. P. Hill (18 Oct 01)

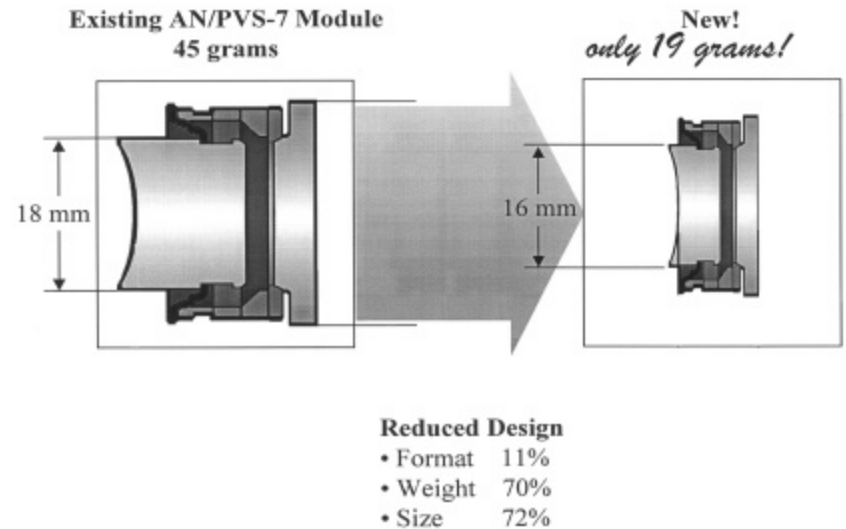
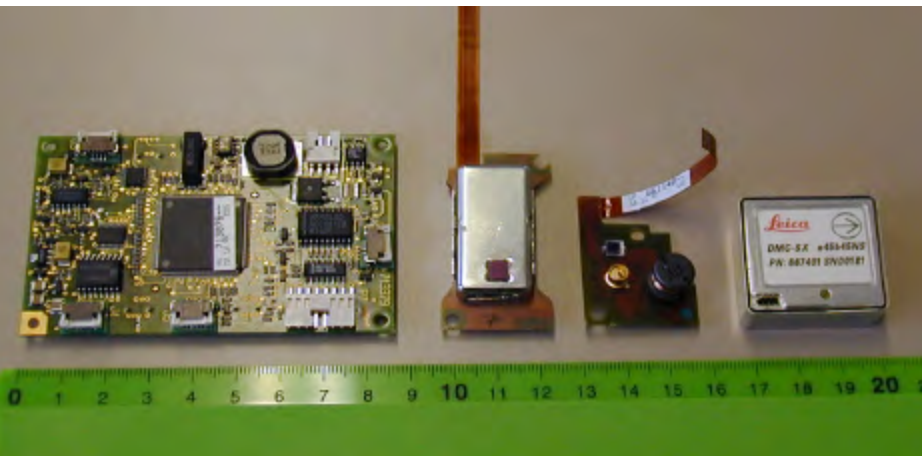
Man-sized

- 1,964 (10% reflectivity)\*

\* Visibility <7 km

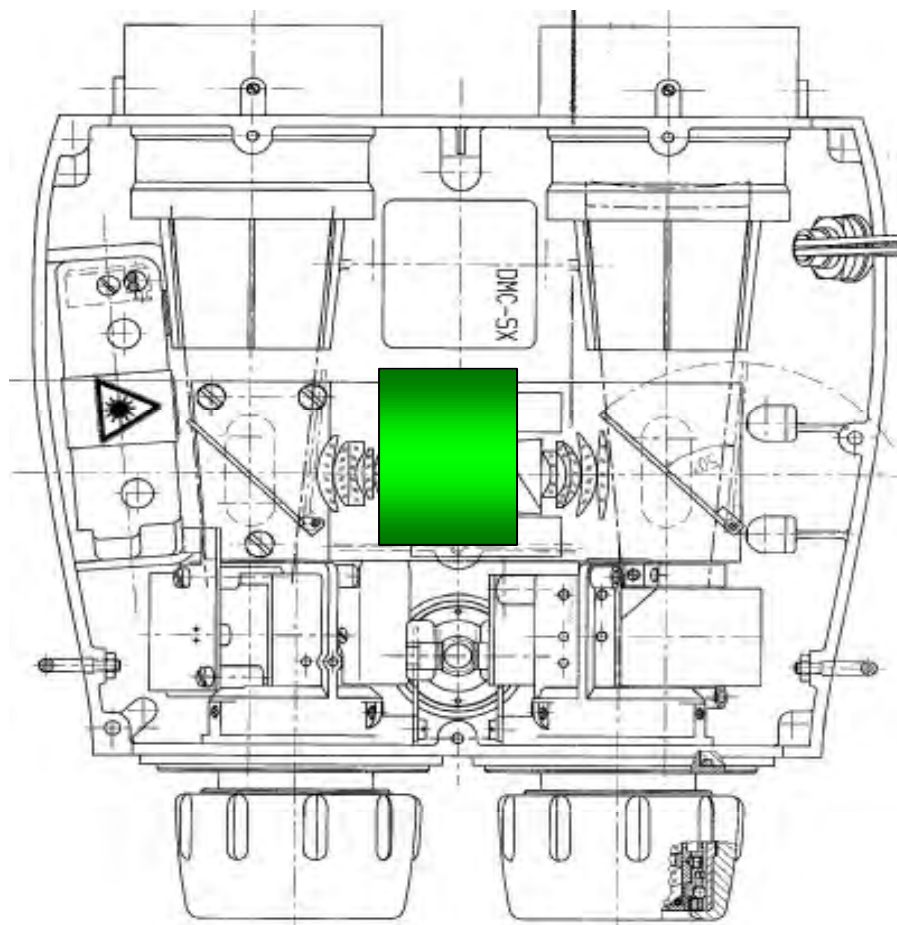
# ***VECTOR/VIPER with Integrated Night Vision***

- Technological Enablers
  - breakthrough in miniaturization of Leica LRF technology
  - introduction of a new generation of Leica digital magnetic compass
  - availability of miniaturized image intensifier tubes



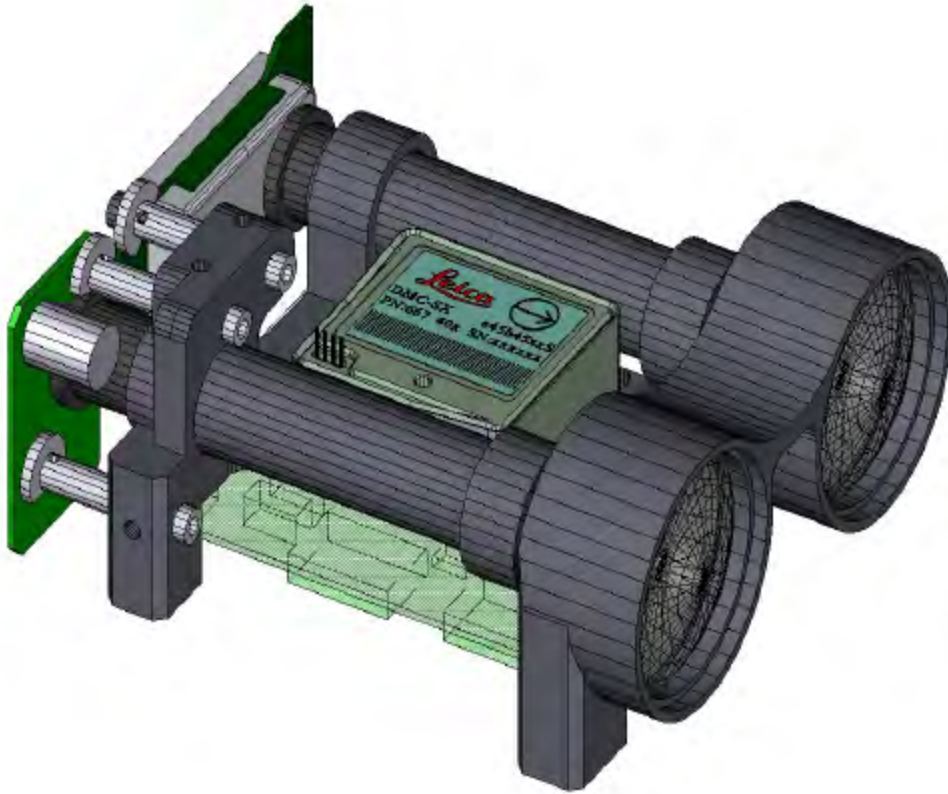
# ***VECTOR Night Layout***

---



# ***Laser Rangefinder/Digital Magnetic Compass Module***

---



## ***Range***

- Ranges up to 2500/5000 m
- Wavelength 905 nm and 1550 nm
- Class 1 Eye Safe  
(ANSI Z136.1-2000 & EN 60825-1 1994)

## ***Heading & 2-axis tilt***

- Azimuth accuracy 0.5°, independent of elevation and bank positions
- Elevation and bank up to +/- 80°
- Built-in 3D magnetic compensation

## ***Physical characteristics***

- L x W x H: 3.9 x 3.1 x 1.7/4.3 x 3.9 x 2.0 in
- Weight (as shown): ≈ 8/12 oz.

# ***LRF-DMC Module, Top View***

---





# ***MK47 and VIPER Operators***

---

**Leica  
LRF  
module  
in LVS**



**VIPER/VECTOR**



# ***Programs Using Leica LRF Modules***

---

## US Programs

MK 47 Grenade Launcher (LVS)

MK 19 Grenade Launcher FCS (SAFCS II)

OICW (LRF short list)

Proposed Land Warrior MFLS

## European Programs

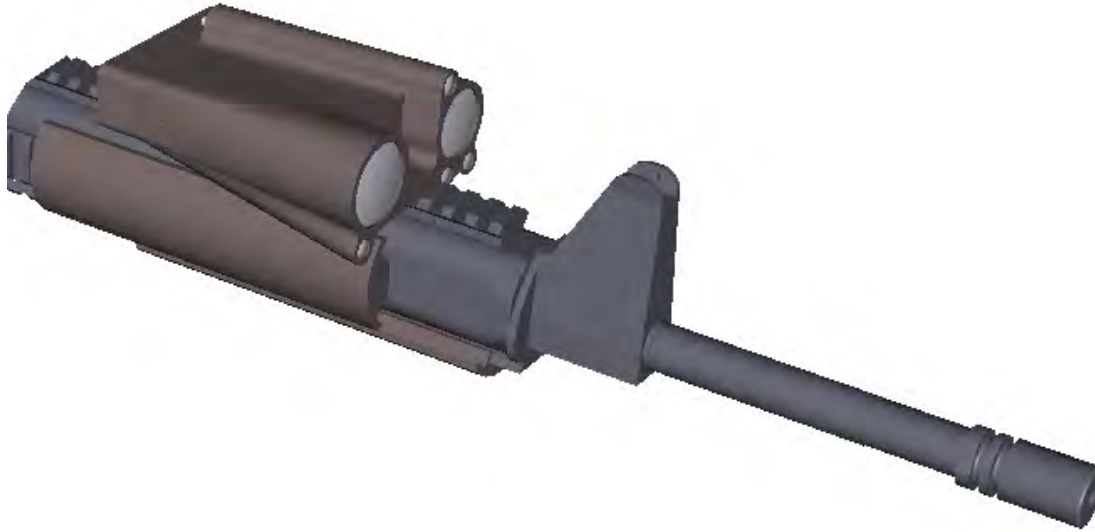
FIST (UK)

IdZ (Germany)

FALIN (France)

# ***Multi-Function Laser System***

---



5 laser functions

Weight ~ 16 oz

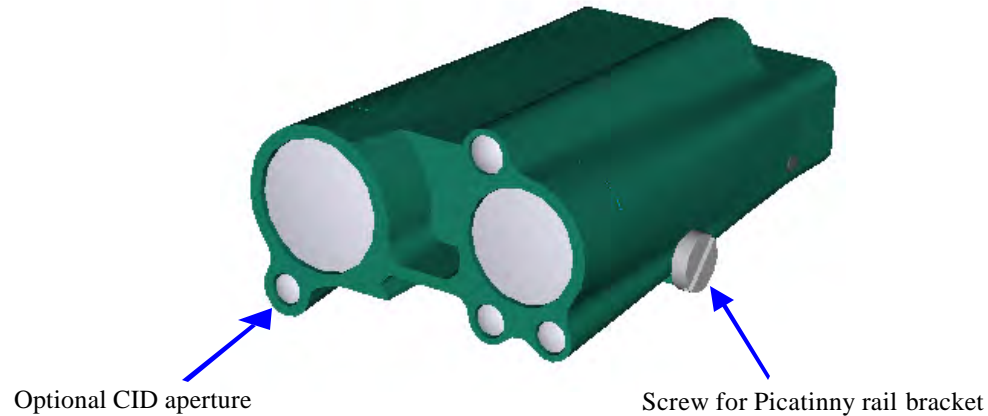
CVAM

Dimensions ~ 4.7 x 3.7 x 1.9 in.

Optional CID

# ***Proposed Land Warrior MFLS***

---



LRF: >2,500 meters

Visible Aiming Laser

NIR Aiming Laser

NIR Illumination Laser

TES (MILES)

CVAM

# ***Our Headquarters are in Switzerland's Rhine Valley***

---



Heerbrugg,  
since 1921  
(former Wild  
Heerbrugg)



Heerbrugg

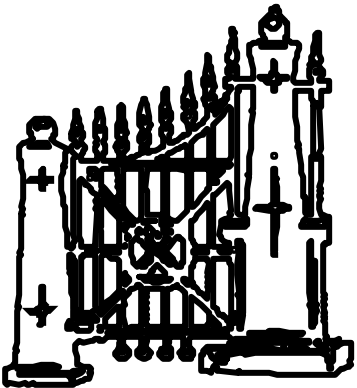
**Leica**  
Geosystems



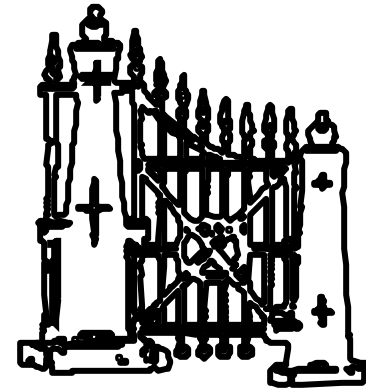
# Welcome to Leica Geosystems AG





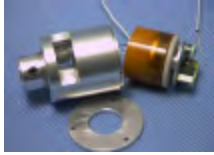


# The Value of Systems Engineering and Integration in OCSW Development



John Edwards  
TACOM-ARDEC

# Objective Crew Served Weapon *Technology & Design Innovations*



**Mini Electronic Time Fuze w/ Point  
Detonating/Self Destruct Capability**



**Precision Air-Bursting  
25 mm Munition, 2 km Range**



**Armor Piercing Munition**



**Ammunition Velocity Correction**



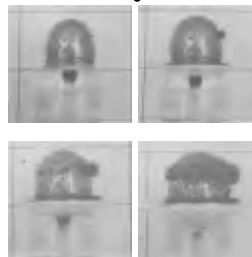
**Impulse Averaging Soft Recoil  
(No Sandbags Required)**



**Thermal Target  
Tracker**



**OICW's 1 km  
Thermal Module**



**Controlled Fragmentation  
Warheads**



**Lightweight (< 38 lb)  
2-man Portable System**

# OCSW ATD EXIT CRITERIA

## Range Measurable

	<u>BASELINE(S)</u>			<u>OCSW ATD</u>	
	<u>MK19</u>	<u>M2</u>	<u>M240B</u>	<u>THRESHOLD</u>	<u>GOAL</u>
<b>I. <u>LIGHTWEIGHT</u></b>					
-SystemWeight (no Ammo), Lbs	144lb	128 lb	43.4 lb	57 lb	38.6 lb
- Crew (2 Man) Portable Modules (Transport Module Weight w/ ammo), Lbs	76 lb	84 lb	24.2 lb	38 lb/person	35 lb/person
<b>II. <u>LETHALITY</u></b>					
- Accuracy / Dispersion) (deflection error @ 600m)	-	-	-	2 mils	0.5 mils
- Fuze Function Set by Fire Control	N/A	N/A	N/A	Single Shot	Full Auto
- Air burst Point Range Error (known range, 600 m)	N/A	N/A	N/A	10 m (+/- 5m)	4 m (+/- 2m)
- Defeat of Defilade Target	Minimal	None	None	Yes	Yes
- High P(i) (*1)	x	y	z	3x / 12y / 8z	6x / 24y / 16 z
- Armor Penetration (at 0 deg. obliquity)	2"- 3" RHA @ 1,500 m	3/4" HHA @ 1,500 m	1/2" HHA @ 800 m	2" RHA (*2) 1,000 m	2" HHA (*2) 2,000 m
- P(h), Lt Vehicle Target @ 1,000m (Two 5 rd bursts; stationary 2.3 x 2.3m target)	-	-	-	.35 1000 m	0.75 2,000 m
<b>III. <u>DAY / NIGHT CAPABILITY</u></b>				(modular interface to OCSW) (*3)	
- Demonstrate Thermal Module					
<b>IV. <u>LAND WARRIOR COMPATIBILITY</u></b>				LW Interoperable	LW Wireless Interoperability
<b>Based on Government approved Modeling &amp; Simulation:</b>					
<b>V. <u>SURVIVABILITY</u></b>					
- Casualty Reduction (*4)				40 % Reduction	90 % Reduction
<b>VI. <u>SUSTAINABILITY</u></b>					
- Lbs Ammo/ "Kill" (*1)	111	117	25	20	6
<b>VII. <u>AFFORDABILITY</u></b>					
- Cost /"Kill" (Ammo) (*1)	\$1,420	\$600	\$130	\$300	\$130
- Design to Avg Unit Production Cost (HE Ctg)	\$ 24 (15)	\$ 2	\$ .55	\$ 29 (incl. Facility)	\$ 22

## Simulation Measurable

\* 1 - Weighted AMSAA Analytical Model: Avg: 200-2000m; Standing/Prone/Defilade (5/20/75 %). "Kill" refers to fraction of threat squad incapacitated; current systems have significantly less incapacitation capability against defilade targets. AMSAA model not representative of actual operational engagement scenarios.

Rev: 21 Jul 98  
3/03/00 - JHE

\* 2 - Test Warhead Only (no fuze). ORD will require 2" HHA capability.

\* 3 - FUE Goal is 2,000 meter capable thermal module. ATD will assess weight vs. range of available uncooled thermal sensors.

\* 4 - Reduction from small arms inflicted casualties in TRAC-WSMR CASTFOREM high resolution scenarios.

# System Error Budget

## OCCASION-TO-OCCASION

Range determination error

**Air Density** (Air Pressure & Air Temperature)

**Coriolis (earth rate)** (Latitude & Firing Direction)

Cant Angle

Cant Zeroing

Site Angle

Site Angle Zeroing

Muzzle Velocity Error (Temp.)

Fire Control Solution

Static Boresight (weapon)

Static Boresight (FCS)

Jump - Vertical

Jump - Horizontal

Gun Zeroing

Cross Wind Velocity

Cross Wind Direction

Range Wind Velocity

Range Wind Direction

## BURST-TO-BURST (B-B)

Initial Aiming

B-B Dispersion - Vertical

B-B Dispersion - Horizontal

T&E accuracy error (vertical)

T&E accuracy error (horizontal)

Visual Resolution

Muz. Vel. (lot-lot)

## WITHIN-BURST (W-B)

Muzzle Velocity (within lot)

Muzzle Velocity Correction

W-B Weapon Dispersion - Vertical

W-B Weapon Dispersion - Horizontal

Ammunition Dispersion - Vertical

Ammunition Dispersion - Horizontal

Drag Variability

Projectile Mass Variation

MV Correction Algorithm

Fuze Timing

# USER Evaluation of Operational Utility



Nov 2000



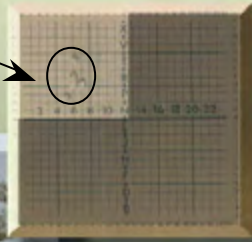
# Exterior Ballistic Performance

## Minimal Weapon Dispersion

$S_{xave} = 0.5 \text{ mrad}$ ,  $S_{yave} = 0.5 \text{ mrad}$

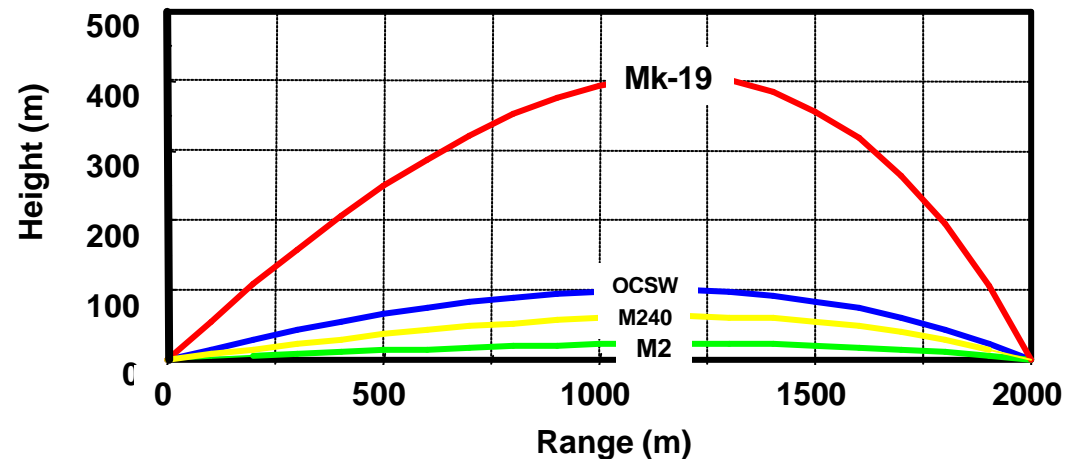
5 round burst, no sandbags, 100m target

$S_x = .32$ ,  $S_y = .37$



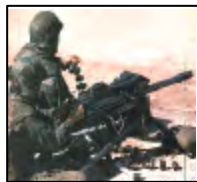
Time of flight to 2000 meters  
half that of the MK19.

- Ammunition dispersion demonstrated at less than 0.2mils from a Mann barrel.
- Ammunition dispersion demonstrated at less than 0.4 mil from the OCSW weapon in full automatic fire.



# *CREW SERVED WEAPON SYSTEMS*

## *Heavy & Medium Machine Gun Comparisons*



**MK 19**  
**(40 mm)**



**Striker**  
**(40 mm)**



**M2**  
**(.50 Cal)**



**M240B**  
**(7.62 mm)**



**OCSW**  
**(25 mm)**

<b>GUN</b>	76 lbs		84 lbs	27.3 lbs	27/23 lbs
<b>MOUNT</b>	68 lbs	70-80 lbs (System)	44 lbs	15 lbs	11/9 lbs
<b>FCS/Thermal</b>	5 lbs		5 lbs	4.5 lbs	7/6 lbs
<b>AMMO</b>	59.5 lbs <u>(48 rds)</u>	59.5 lbs <u>(48 rds )</u>	38 lbs <u>(100 rds)</u>	18 lbs <u>(200 rds-**) </u>	28/28 lbs. <u>( 62rds)</u>
<b>TOTAL</b>	<b>208.5 lbs</b>	<b>139.5 lbs</b>	<b>171 lbs</b>	<b>64.8 lbs</b>	<b>73/64 lbs</b>

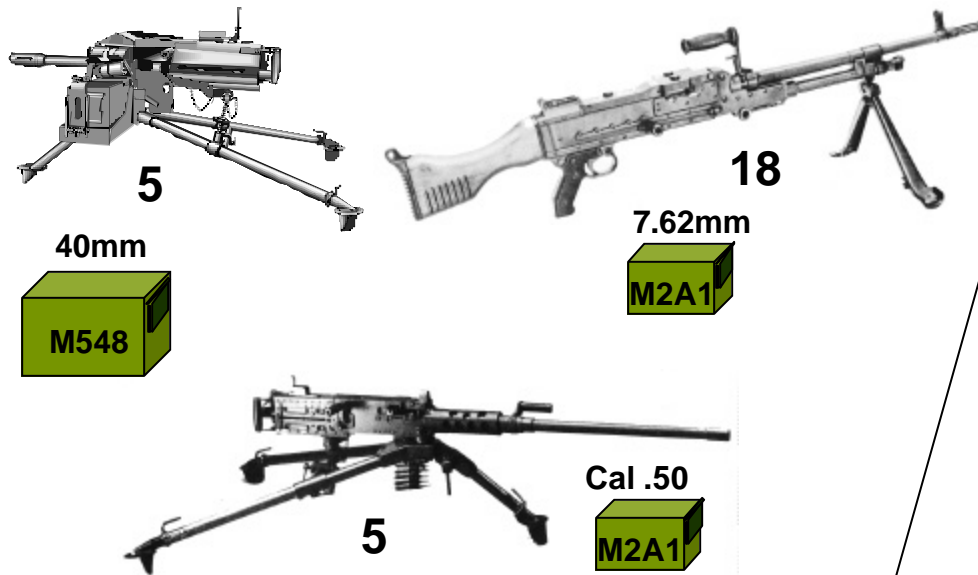
*OCSW Weight  
60 % < M2, MK19*

*OCSW Defeats  
Defilade Targets*

**Current/FUE**

# *Logistics Comparison (Weight and Portability)*

## Conventional Weapons



28 Weapons

2136 Lbs

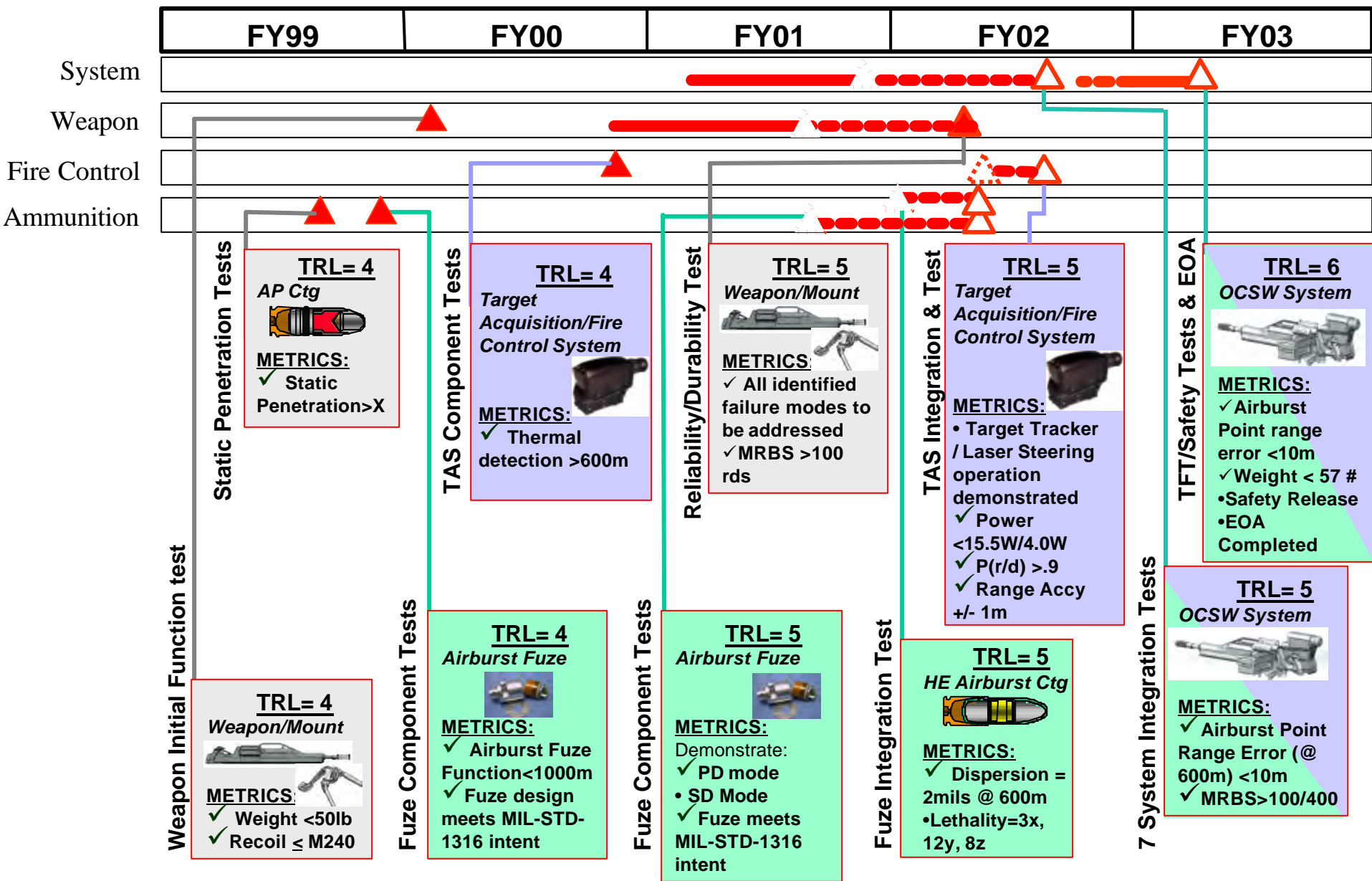
## OCSW Weapon



28 Weapons

1134 Lbs

# Objective Crew Served Weapon System



# OCSW System Integration Summary

- 5 of the 7 System Integration Tests have demonstrated maturity growth led by General Dynamics AS group
- Remaining 2 Systems Integration Test will increase reliability and refine dynamic subsystem interaction



Unclassified



# 2002 International Infantry & Joint Services Small Arms Systems Symposium

**Delivery of Non-Lethal Mortar Payloads  
by Mortar Systems**

**Joint RDT&E Pre-Milestone A Program**

**14 May 2002**

**Matthew Evangelisti  
USA TACOM-ARDEC**

**973-724-2851**

**mevange@pica.army.mil**



**T**ank-automotive & **A**rmaments **COM**mand  
*Committed to Excellence*



# Background

Existing Non Lethal Capability Set range-limited. In 1998, Joint Non Lethal Weapons Directorate sought industry proposals for long range non-lethal delivery systems. Two winning proposals both mortars solutions. Contracts awarded 3 years ago this month. September 2000, ARDEC asked to manage overall program



# The Challenge

Non-lethal Mortar must meet a stringent Kinetic Energy Criterion: No portion of the cartridge can impact the target area with a KE greater than 58 ft-lbs. Typical mortar cartridge weighs several pounds and impact velocities exceed 300 ft/sec. Conventional design concepts won't work, positive measures must be taken to mitigate the KE before impact.

# Current Status

At the present time, the IPT is evaluating the efficacy of several Terminal Kinetic Energy approaches being investigated, and starting to define the overall cartridge design. There are many issues and challenges to be met in applying mortars technology to this requirement.

We are working with the OIWC Team as they have a similar problem.

# *DoD Directive 3000.3, 9 Jul 96*

## *Policy for Non-lethal Weapons (NLW)*

. . . **Designates** . . . Commandant of the Marine Corps  
Executive Agent for the DoD NLW Program . . .



. . . **Defines NLW** . . . “weapons that are explicitly designed and primarily employed so as to incapacitate personnel or materiel, while minimizing fatalities, permanent injury to personnel, and undesired damage to property and the environment.”

. . . **Directs** . . . Services to participate in NLW program



# Army Roles in NLW



## *Single Proponent for U.S. Army Non-Lethal Applications*

- The U.S. Army Military Police School (USAMPS, at Fort Leonard Wood, MO) is the designated single proponent for Army Non-Lethal Applications, effective 12 Sep 00.
- USAMPS will serve as the U.S. Army Training and Doctrine Command's single voice for all developments and initiatives to field NL capabilities.

# Army Roles in NLW



## *Project Manager for*



## *Mines, Countermine and Demolitions*

- The Project Manager – Mines, Countermine and Demolitions (PM-MCD), located at Picatinny Arsenal, NJ, has program management responsibility for Army Non-Lethal Materiel programs, and establishing the Army's Non-Lethal Capability Sets.
- PM-MCD sits on NATO LG 9 on Combat Engineering.



## *Systems Manager for*



## *U.S. Army Non-Lethal Technology Integration*

- The Tank-automotive and Armaments Command - Armament, Research, Development and Engineering Center (TACOM-ARDEC), Close Combat Armaments Center (CCAC), located at Picatinny Arsenal, NJ, has responsibility for leading coordination of Army NL Technology development.
- CCAC sits on NATO LG 3, Close Combat Infantry.

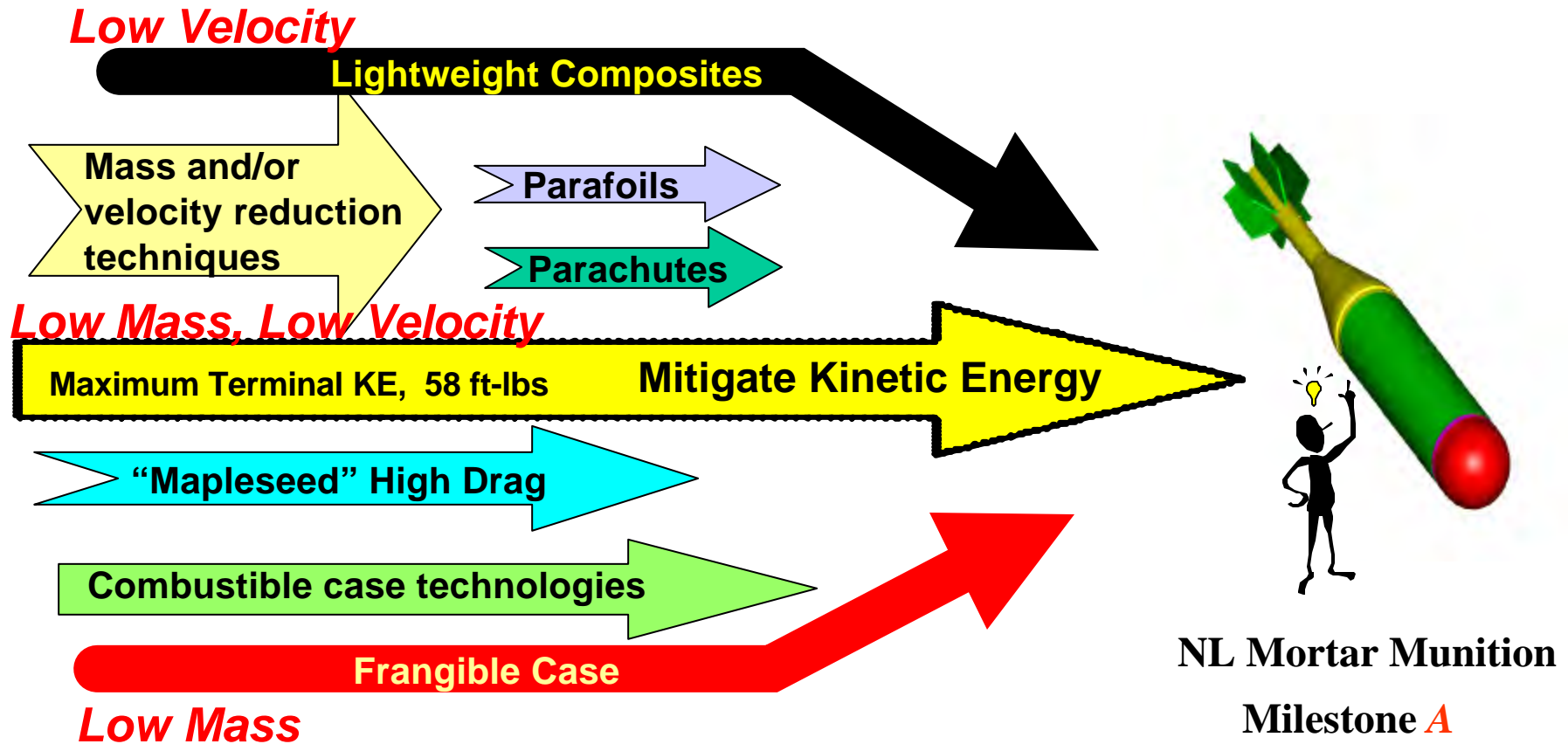
# **K.E. mitigation techniques**

- Several K.E. mitigation techniques have been defined
  - Lightweight Composites
  - Parachutes/Parafoils
  - “Mapleseed” High Drag
  - “Brooming”
  - Frangible Case
  - Combustible Case
  - Any other mass and/or velocity reduction technique

# NL Down Select Options

To Get To End State

V  
i  
a  
b  
l  
e  
  
C  
a  
n  
d  
i  
d  
a  
t  
e  
s



**Key objective: mitigate Terminal Kinetic Energy**

A major challenge will be to come up with a cartridge that can meet all applicable weapon Requirements without exceeding non-lethal Kinetic Energy Criteria. All approaches, weight reduction, combustible cartridge, velocity mitigation, etc will be explored.

# Requirements

## MS A Exit Criteria

<b><u>Criterion</u></b>	<b><u>Threshold</u></b>	<b><u>Goal</u></b>
• Cartridge Size	81mm	60 – 120mm (Scaleable)
• Range	200-2500m	200-5100m
• Maximum Terminal KE	58 ft-lbs	25 ft-lbs
• Payloads	Liquid, Aerosol, Powder, Solid	Same
• Area Coverage	Type of Payload Dependent	25m <sup>2</sup> min
• Delivery Accuracy	One PE*<15M up to 1500m	One PE*<15m up to 1500m & <1% beyond 1500m

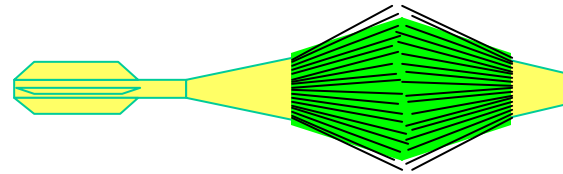
\* PE= Probable Error





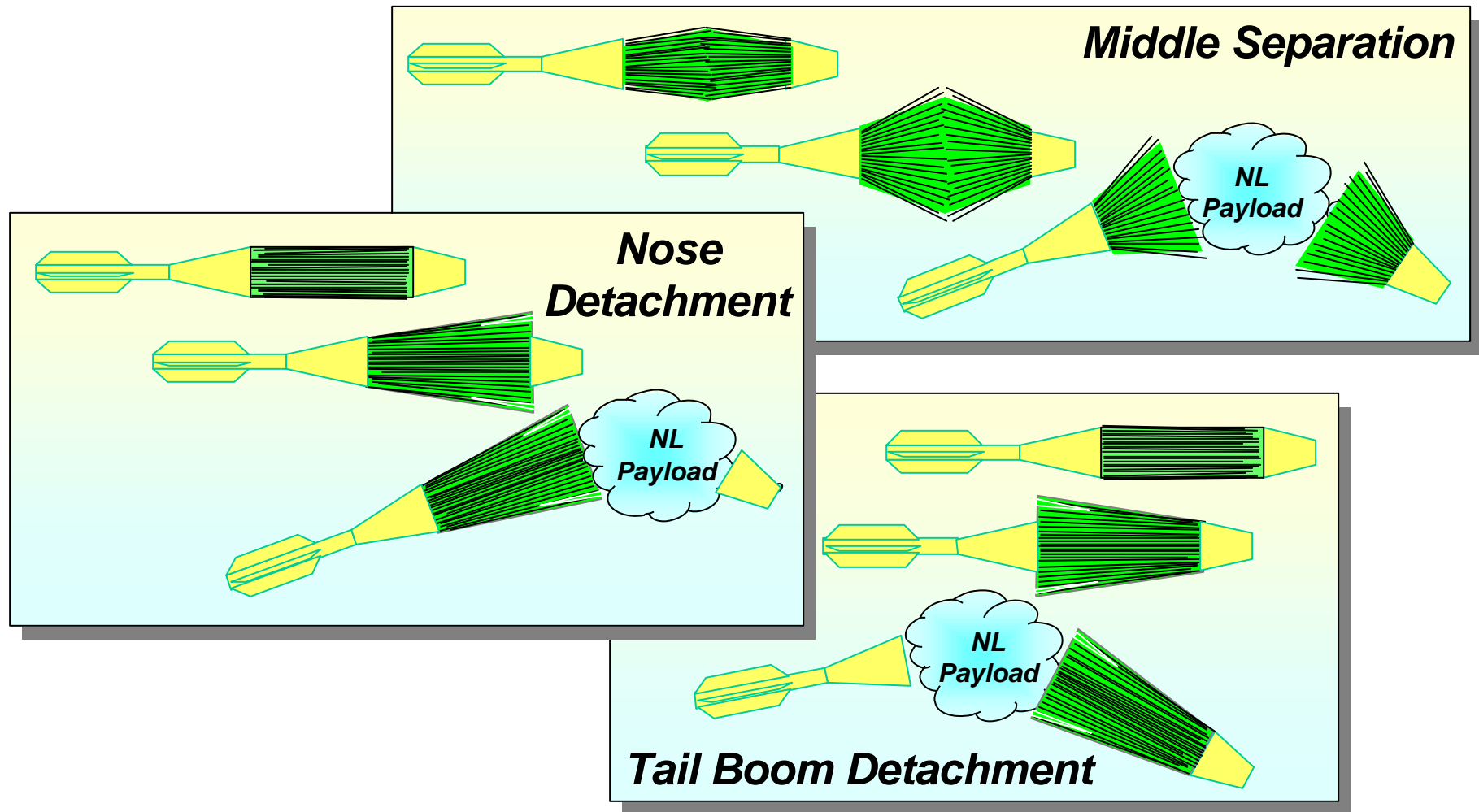
## ***Brooming Composite Casing Concept***

- *Filament Wound or Pultruded Shell*
- *Low Cost GL/Polymer Materials*
- *Stress Induced Matrix Disruption and Resulting Fiber Brooming*
- *Casing breakup initiated via gas generator*
- *Solid, Liquid, Powder Payload Flexibility*
  - *Bladder*
  - *Sleeve*



# **M2 Mass Mitigation Approaches**

## **Brooming Concept Execution Options**





## 45 Degree S-Glass Cylinder Burst Test Specimen



# Mapleseed

## Rotor Deployment Sequence



- Testing of the mapleseed scheme to optimize its drag and/or lift.
- UDLP began investigation of cost effective ways to fabricate the composite bodies and nosecones.

## ARMTEC work :

Esterline

# ARMTEC

- Develop a method for successful launch of NL payload carrier from 120mm mortar system. High angle of fire weapon system optimal for MOUT Operations.



- Establish payload capability for this system.
- Establish the circular error of probability (CEP) for payload.
- Work with ARDEC in follow-on development of payload and deployment system.

Proprietary Data Statement

Esterline

# ARMTEC

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# Velocity Mitigation

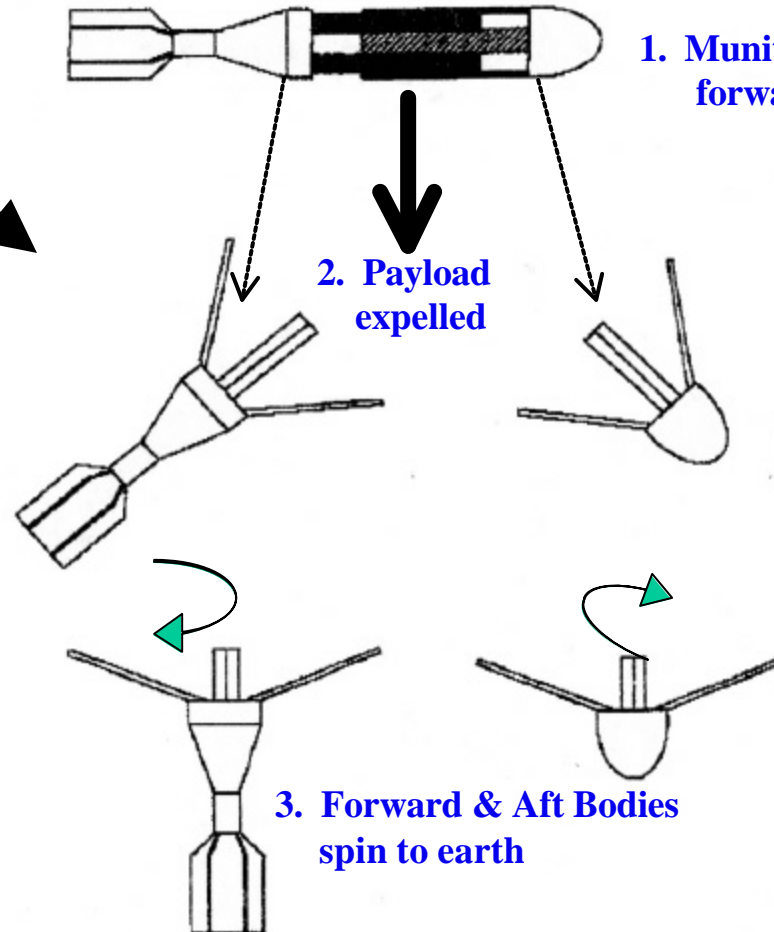
## In House NL Mortar Concepts

### Double Vane Decelerator \*

#### OPERATIONAL SEQUENCE



8 Interlocking Vanes form centerbody



Interlocking Vane



#### Upcoming Associated Activities

Jan 02 – Feb 02

May 6

Testing of In-House Design  
phase II

Picatinny & Wright  
Paterson  
“

\*Patent pending



## In House NL Mortar Concepts



## In House NL Mortar Concepts



## TACOM-ARDEC



# Single Parachute-Lightweight Composite

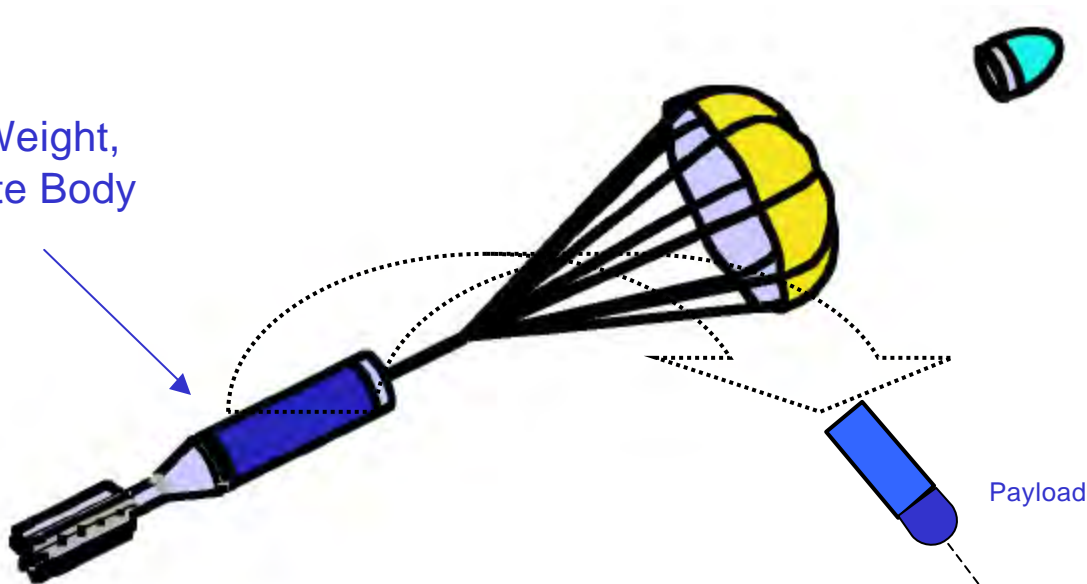


TACOM-ARDEC

In House NL Mortar Concepts

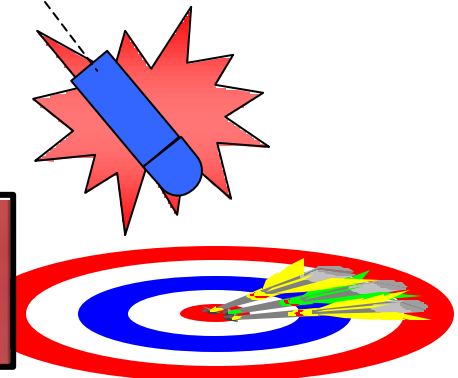
Fuze in rear

Light Weight,  
Composite Body



Payload

Lightweight (composite) Vehicle with  
2 Parachute Delivery



ARL / UDLP / FSAC



# Program Status

- Pre-Milestone A Program
- Bench Tests, Static Firings, Wind Tunnel Testing ongoing
- Milestone A Scheduled for 3QFY03
- Demo Firings 2QFY03: TRL 4



# MOUT ACTD Breaching

**Mr. Adam Fields**

MOUT ACTD Senior Engineer (SETA Contractor)  
US Army Soldier and Biological Chemical Command  
**Natick Soldier Center**

(508) 233-4265

Email: [adam.fields@natick.army.mil](mailto:adam.fields@natick.army.mil)





# Agenda



- MOUT ACTD Overview
- MOUT ACTD Requirements
- COTS Technology Solutions
- Operational Lessons Learned
- MOUT ACTD FY01 Extension
- Future Work







# Background MOUT ACTD Mission



## Improve the operational capabilities of Soldiers and Marines in MOUT

- Evaluate advanced technologies to provide technological dominance in MOUT, including TTPs to employ new capabilities.
- Provide interim capabilities to operational units with TTPs.
- Set the stage for rapid acquisition of selected technologies.





# MOUT ACTD Breaching



- Requirement 30 - Door Breaching
  - non-explosive
  - quick and quiet
- Requirement 27 - Wall Breaching
  - small, fast, simple
  - man-sized hole in concrete walls
  - average soldier/Marine (not Engineers)





# R30A – DOOR BREACHING, MECHANICAL



- Halligan Tools
  - Large and bulky
- Door Jamb Spreaders
  - Hydraulic rams
  - Not robust enough
- **RESIDUAL: DEMTEX Breaching Kit**
  - Halligan tool
  - Bolt Cutters
  - Mini-sledge

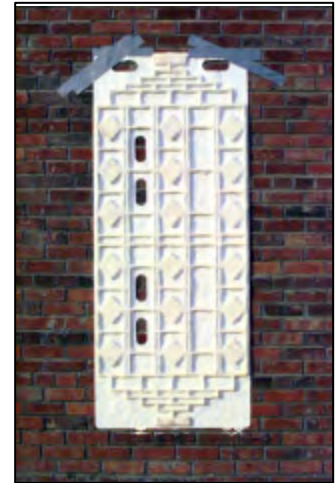




# R27 – WALL BREACHING (1)



- Two COTS products
  - Explosive Cutting Tape (ECT) - EBCo
  - BEAST – H.E.A.T.
- Pre-packaged explosive charge
- Hand emplaced







# R27 - ECT Video





## R27 – WALL BREACHING (2)



- Brick targets
  - Creates man-sized hole
- Concrete targets
  - Creates man-sized hole
  - Rebar grid still intact
  - ***Requires Secondary action to cut remaining rebar grid***
- TRANSITION: ARMY FY03 SEP
  - Infantryman's Wall Breaching Kit







# Wall Breaching System Employment



- (+) Enables soldiers to quickly create a breach wherever they need
- (+) Uses standard and commercial initiation systems
- (+) Soldiers/Marines can be quickly trained
  - Reduces need for Engineers – rifle platoon more capable
  - Soldiers must use only for tasks in which they are trained
- (-) These items are both hand emplaced
  - increases exposure time in “kill zone”
  - follow-on rebar cutting operations increase this exposure time even further
  - Soldiers-in-the-street can be on a level playing field with enemy forces – minimizes US technology advantage





# STANDOFF BREACHING



- Soldier/Marine can create a mobility corridor wherever one is needed
- Troops rapidly enter structure – maintain element of surprise
- Technology advantage AND training advantage indoors
  - night vision
  - room clearing





# R30B – DOOR BREACHING, STAND-OFF EXPLOSIVE



- Rafael Simon Round – declassified Israeli Defense Forces technology
- Rifle launched using high power blank round



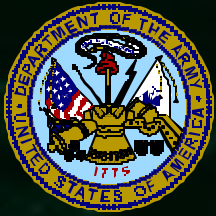
- But...R30 Requirement was for “non-explosive” breaching
- Standoff explosive breaching acts extremely quickly – maintain the element of surprise
- Additional benefit – personnel and booby traps are incapacitated
- Product for window breaching – 1/3 explosive charge





# R30B - Simon Video





# TRANSITION: RLEM Program



- Simon recommended for the US Army Warfighter Rapid Acquisition Program
- Proponent CG, USAIC
- Approved as Rifle Launched Entry Munition (RLEM) Program
- Requirement for bullet trap activation for operational use, blank round activation for training purposes
- Recoil reduced to meet US Army requirements







# WALL BREACHING, STAND-OFF



- Explosively Formed Penetrators (EFPs)
  - examined early in program as a possible means to breach concrete walls and rebar
  - EFPs require large amounts of explosive to propel them to the target
- .50 cal Frangible Ammunition
  - White paper funded to examine feasibility
  - M&S show projectiles can breach concrete and rebar
  - Precision required and quantity of ammo needed restrictive







# MOUT ACTD EXTENSION

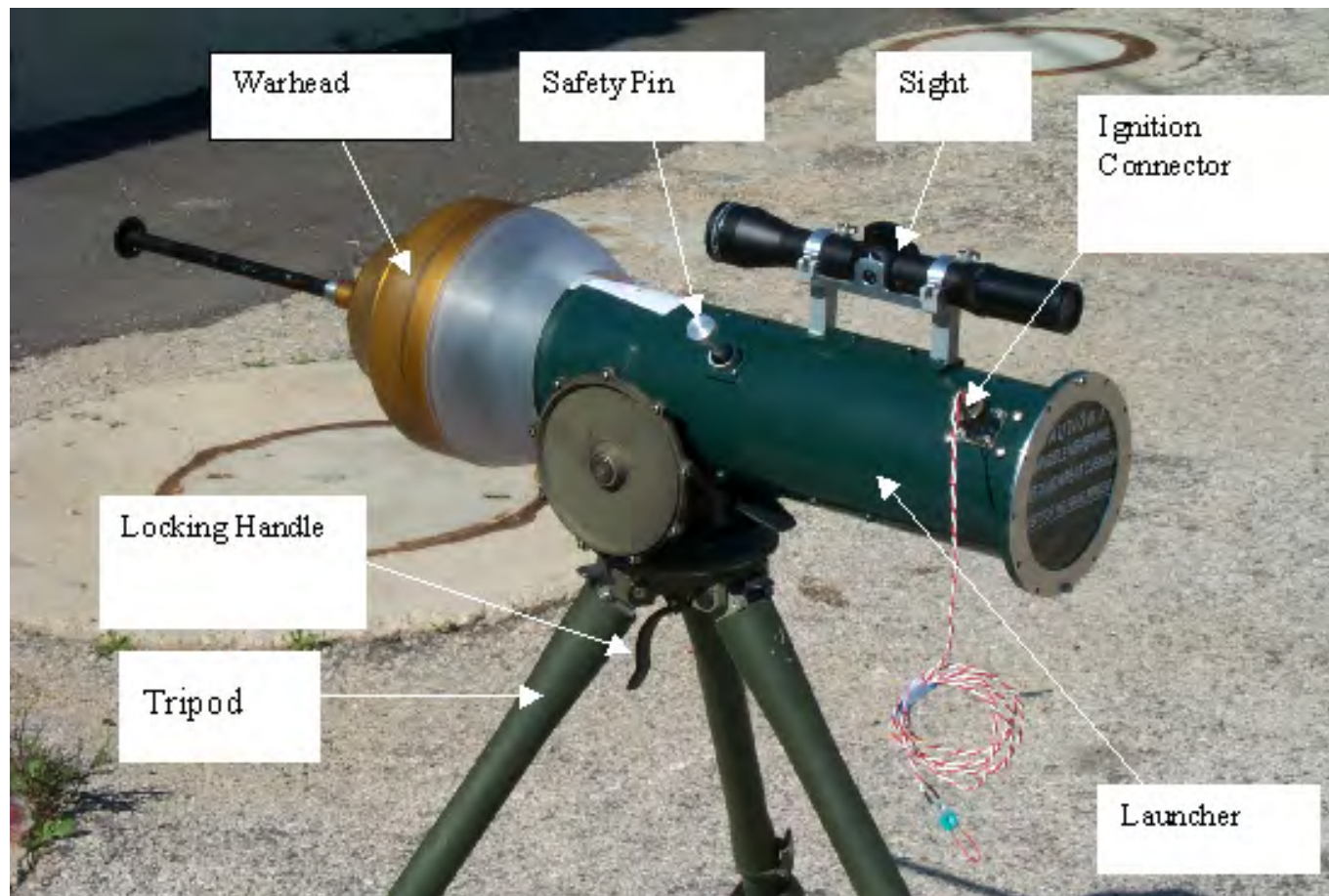


- MOUT ACTD approved for FY01 Technology Extension
- Team able to invest in technology development (vice COTS/GOTS)
- MOUT ACTD funded development of the Wall Breaching Standoff Munition (WBSM)
  - Leverages Simon technology
  - tripod mounted, rocket launched system
  - breaches man-sized hole in double- or triple-layered brick wall
  - Effective range of the WBSM is 15m to 40m





# WBSM System Components





# FUTURE WORK



- Submitted FY04 UFR to continue development of the warhead – to enable defeat of reinforced concrete
- Requirement has been validated and funding needs to be identified
- Will use Rafael patented “Explosive Formed Ring” technology
- WBSM munition to be
  - compatible with US-utilized shoulder launch platforms
  - able to be fired from confined spaces
- USMC/MCWL program called “Wall Breaching round for the SMAW”
  - Difference in stand-off distance





# MOUT ACTD Breaching

**Mr. Adam Fields**

MOUT ACTD Senior Engineer (SETA Contractor)  
US Army Soldier and Biological Chemical Command  
**Natick Soldier Center**

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Email: [adam.fields@natick.army.mil](mailto:adam.fields@natick.army.mil)





DIA 2002 International Infantry & Joint Services Small Arms Systems  
Section Symposium, Atlantic City, NJ - May 13-16, 2002



# 30mm x 173 Ammunition Family

Allan Buckley\* & Pierre H. Freymond  
Oerlikon Contraves Pyrotec AG  
CH-8050 Zurich / Switzerland  
[ocp-marketing@ocag.ch](mailto:ocp-marketing@ocag.ch)

# Threat Spectrum





# 0 mm x 173 Ammunition Family

APFSDS-T



FAPIDS-T



TPFSDS-T



ABM



Notice: SAPHEI-T, TP-T and TP rounds also available

## Major Technologies Involved

Subcaliber: Tungsten Material (Long Rod, Frangible)

Sabot (Plastic Injection Molding)

Full Spin Firing (Long Rod)

ABM: Programmable Fuze

Payload (W-Subprojectile)

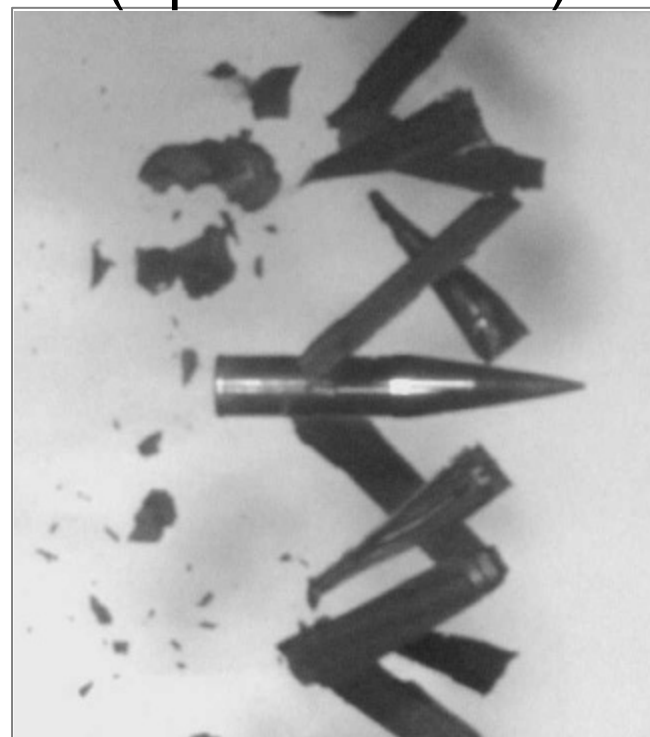
# Subcaliber Technology: About Discarding at Full Spin



Long Rod  
(Fin Stabilized)



Frangible  
(Spin Stabilized)



# 0mm x 173 Long Rod (APFSDS-T) fficacy on Armoured Vehicle APC/IFV

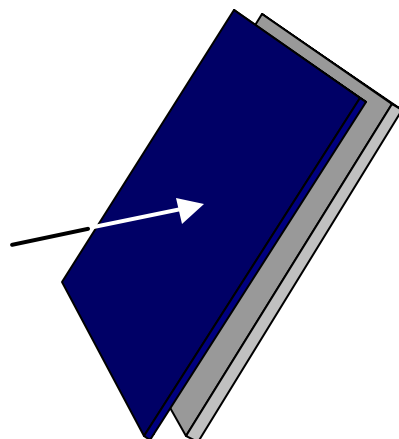
Spaced Armour:

15 mm HHA

30 mm RHA

Obliquity: 45°

Range: 2 km



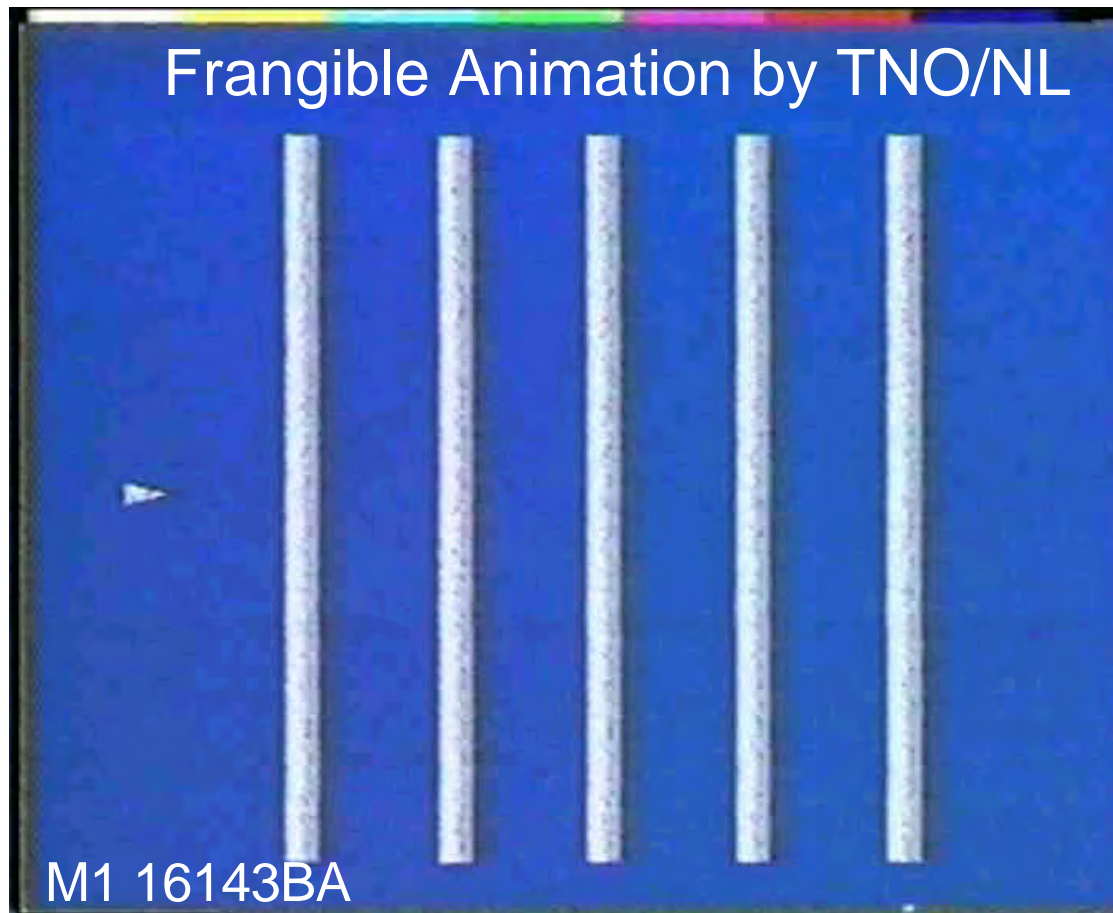


# Frangible Effect

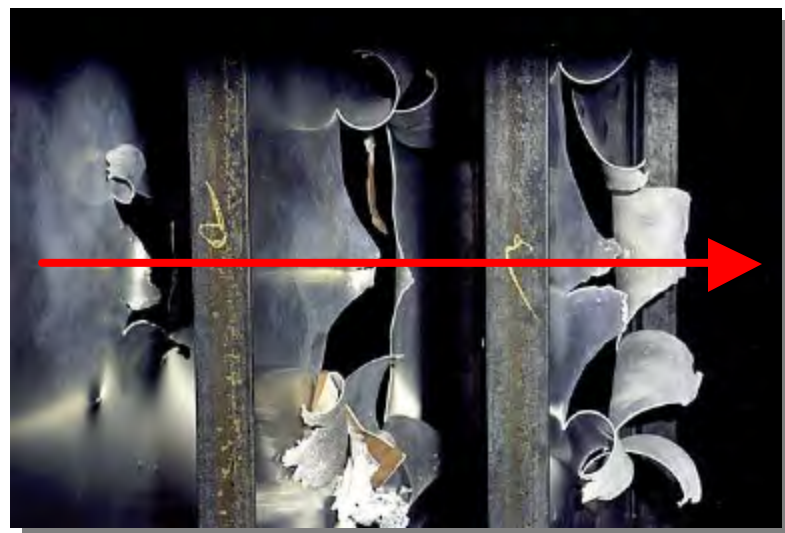
Aircraft Target Simulation S1



Frangible Animation by TNO/NL



M1 16143BA



# APDS Ammunition Effectiveness against Helicopter

Firing Video



M1 15966BA

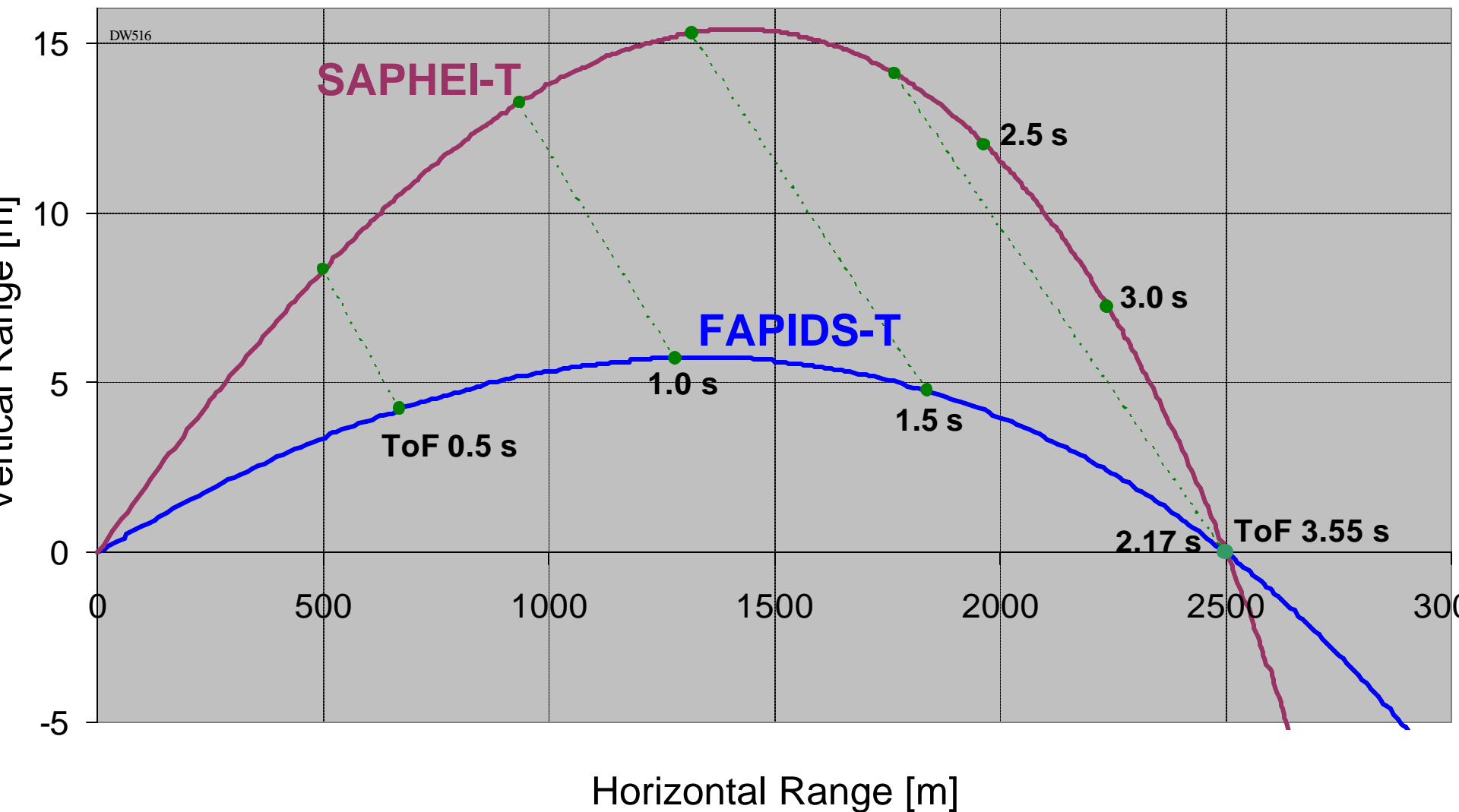
Target after Firing



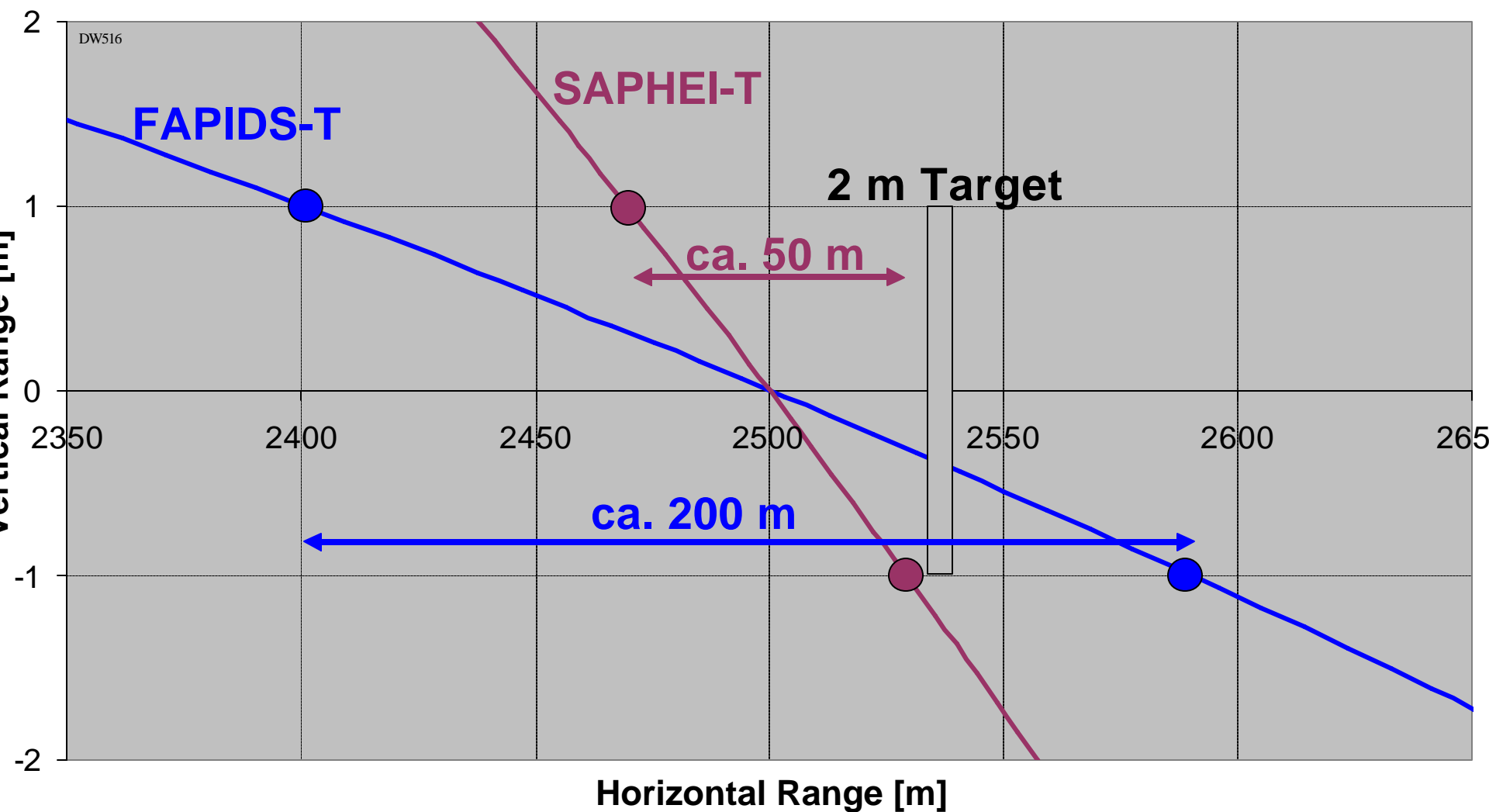
3 Round Burst at 1200 m Range



# 0mm x 173 Ammunition Trajectory Comparison

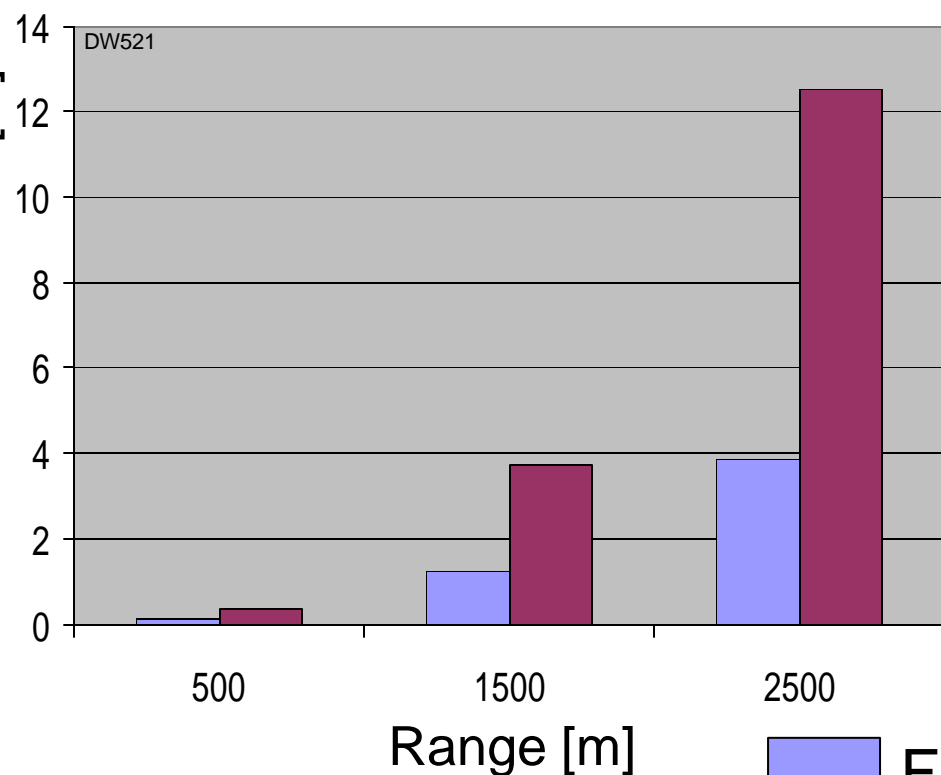


# 0mm x 173 Ammunition ight Range Comparison at 2.5 km Range

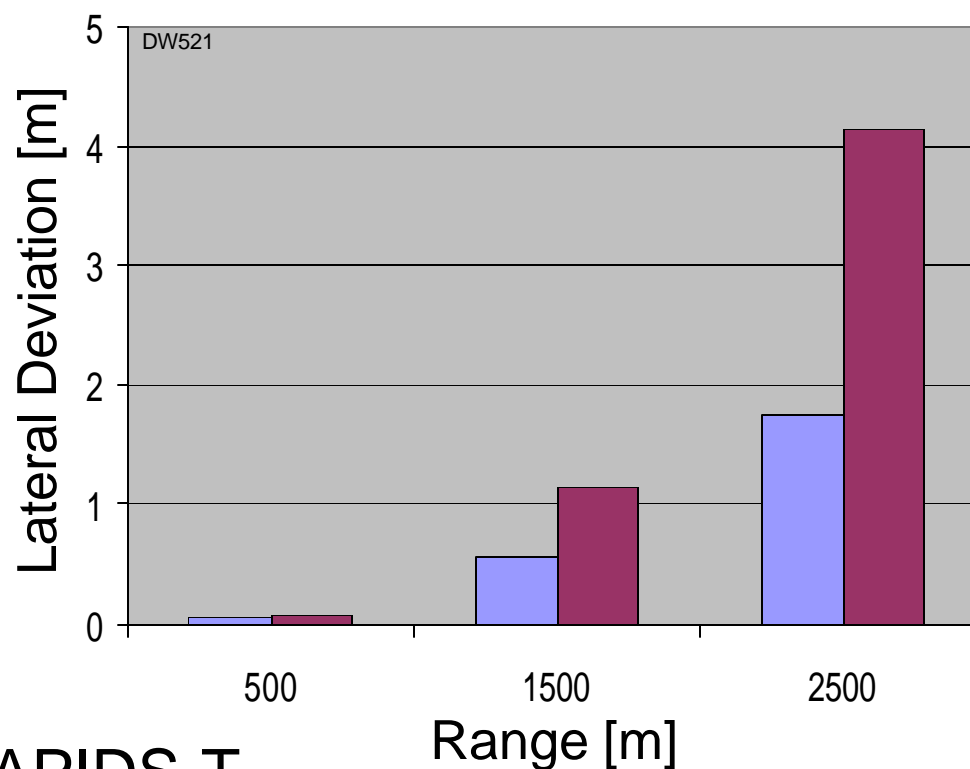




# 0mm x 173 Ammunition Parameter Influence on Ballistics

## 10m/s Cross Wind



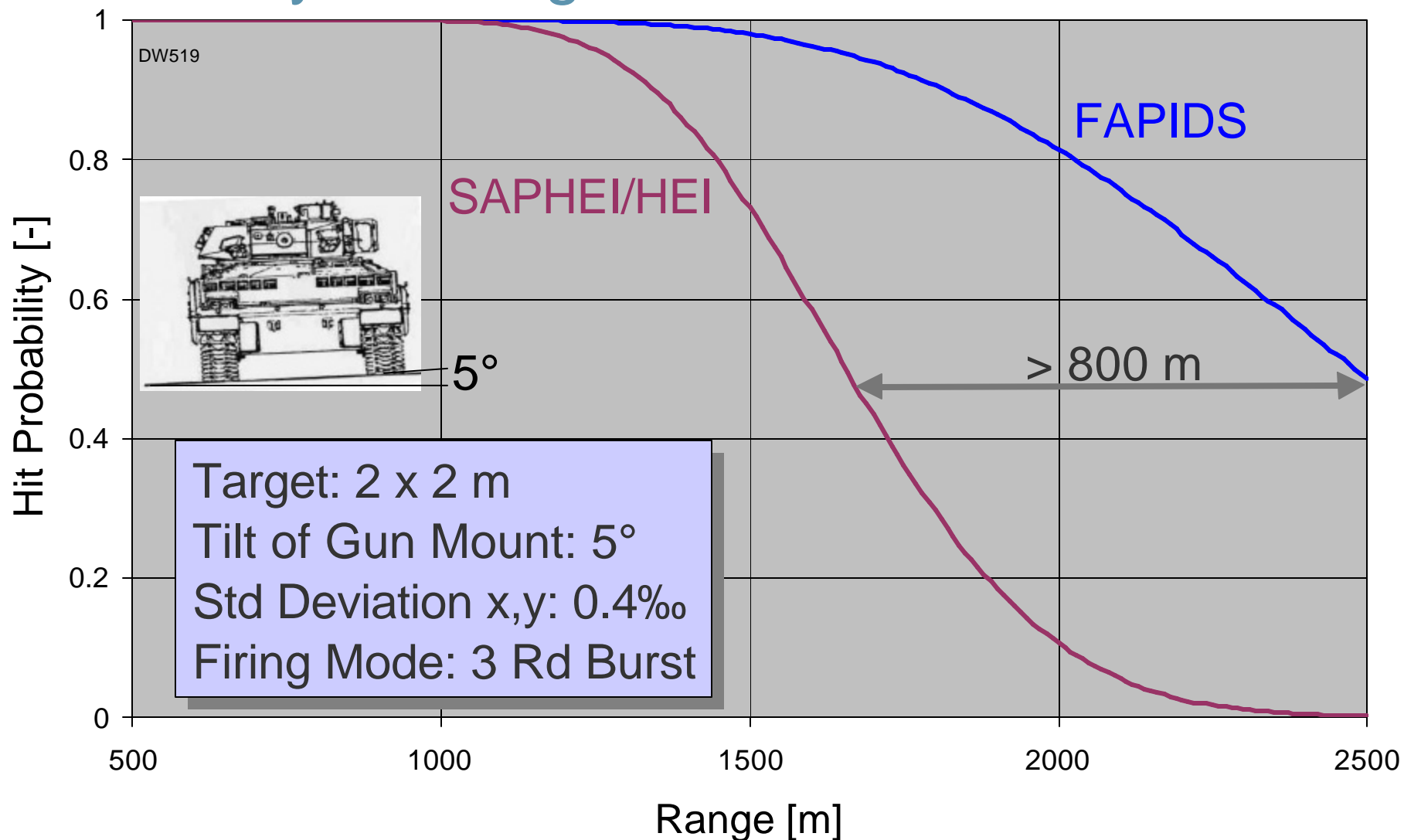
## 5° Side Tilt of Gun Mount



 FAPIDS-T  
 SAPHEI-T/HEI-T

# 0mm x 173 FAPIDS vs SAPHEI/HEI

## Hit Probability vs Range



# mmo 25 mm x 137: Effectiveness Comparison against Urban Target



**HEI-T**



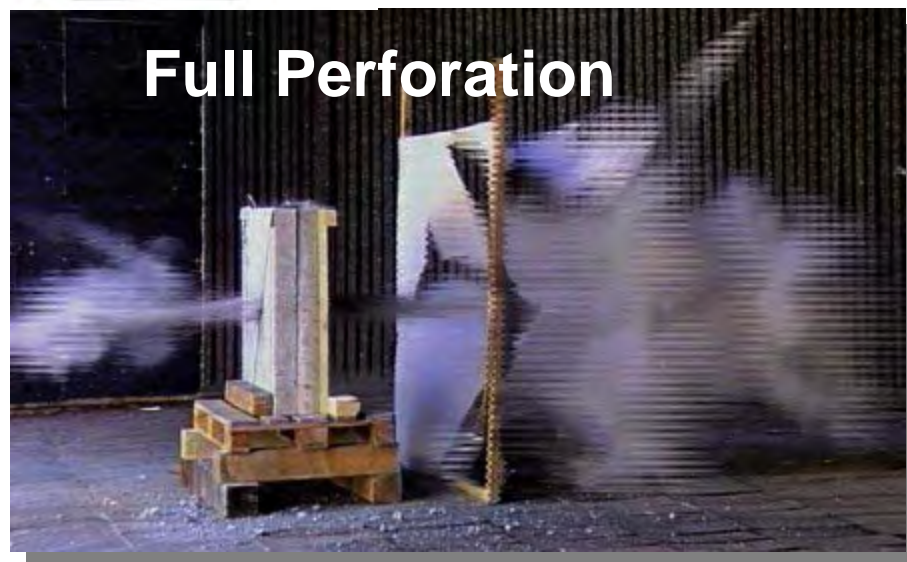
Target: 20 cm (2 x 10 cm) Concrete  
Wall with double steel-structure  
reinforcement at a range of 1500 m



**FAPDS-T**



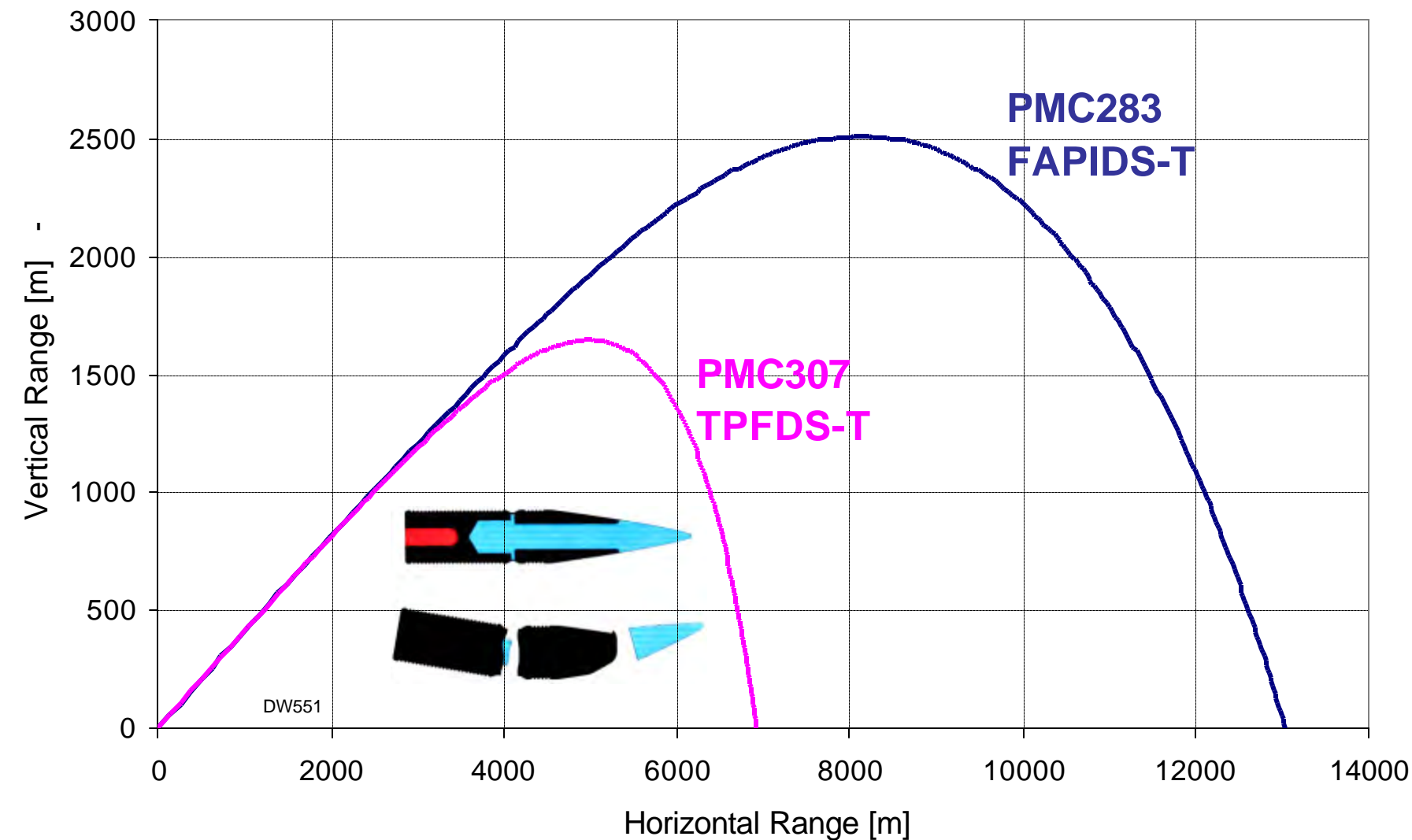
**SAPHEI-T**





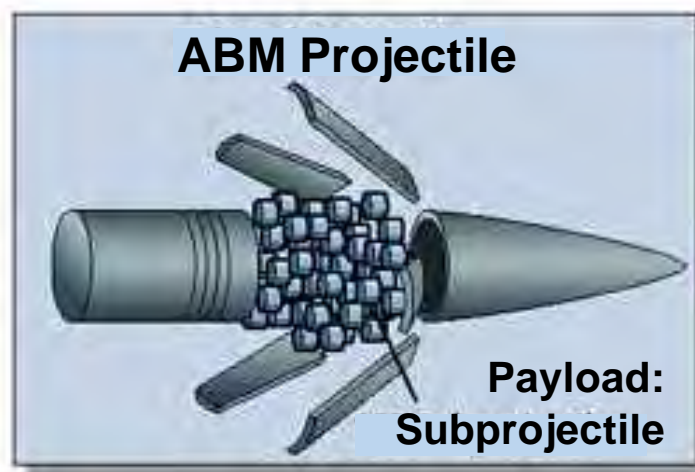
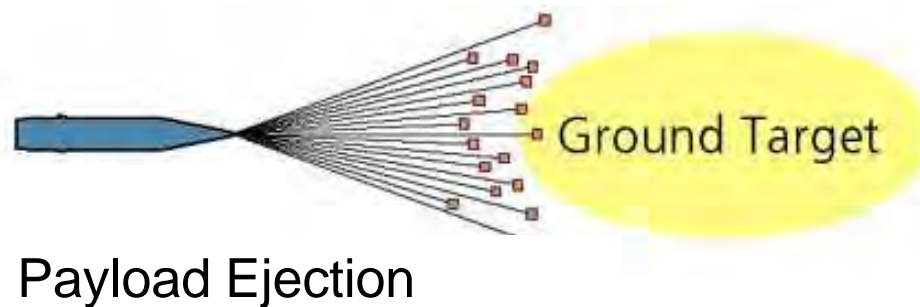
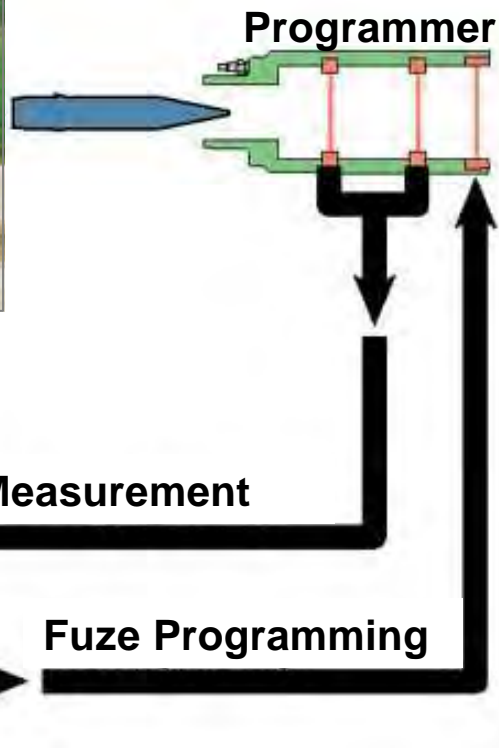
# Ballistic Comparison

## Training TPFDS-T vs Frangible FAPIDS-T Rd



# Air Bursting Munition Technology

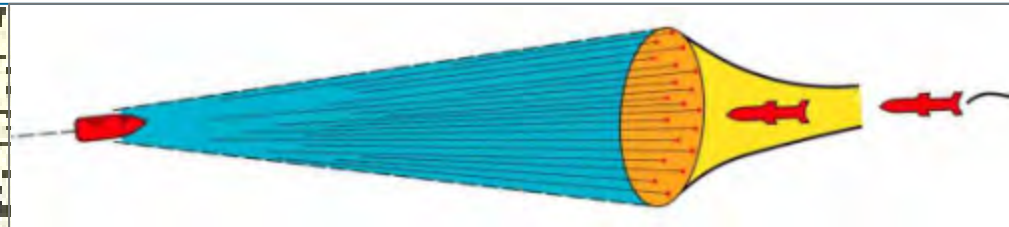
## BM for Infantry Vehicles



# Air Bursting Munition Performances



**Aircraft**



**Missiles**

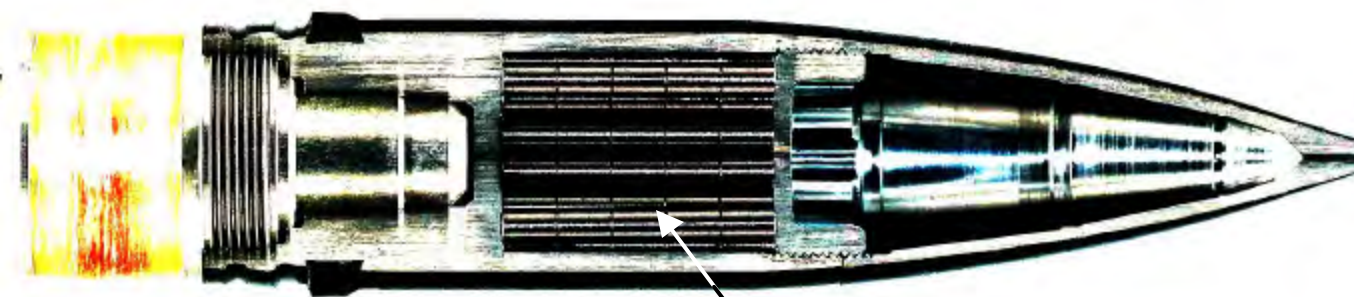


**Soft Targets**



**Tanks**

# One ABM Fuze System (Ahead) - Two Different Warhead Systems

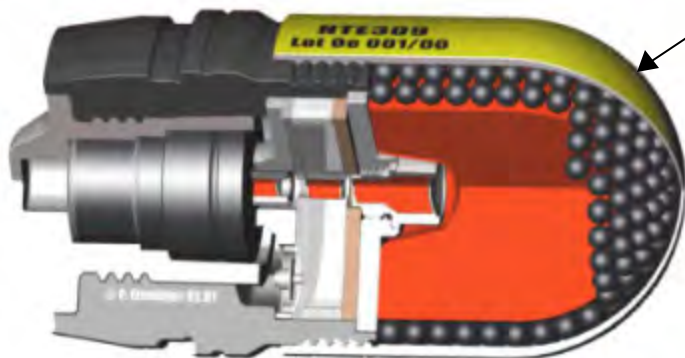


30mm x 173  
(35mm x 228)



Fuze

Subprojectile Warhead  
(KETF: Kinetic Energy Time Fuze)



Blast Fragmentation Warhead  
(HETF: High Explosive Time Fuze)

Scale:

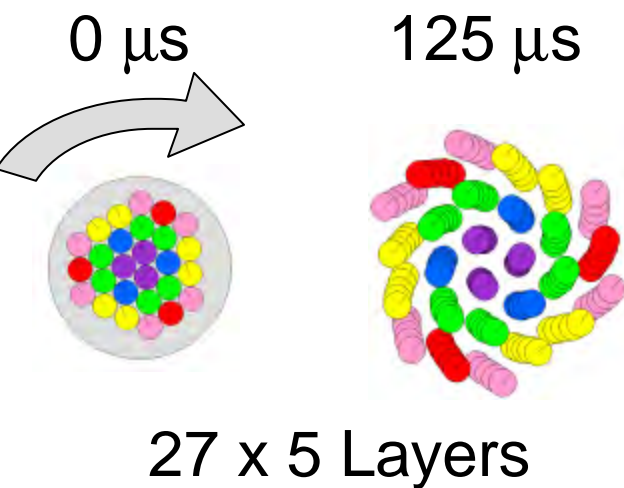


40mm x 53

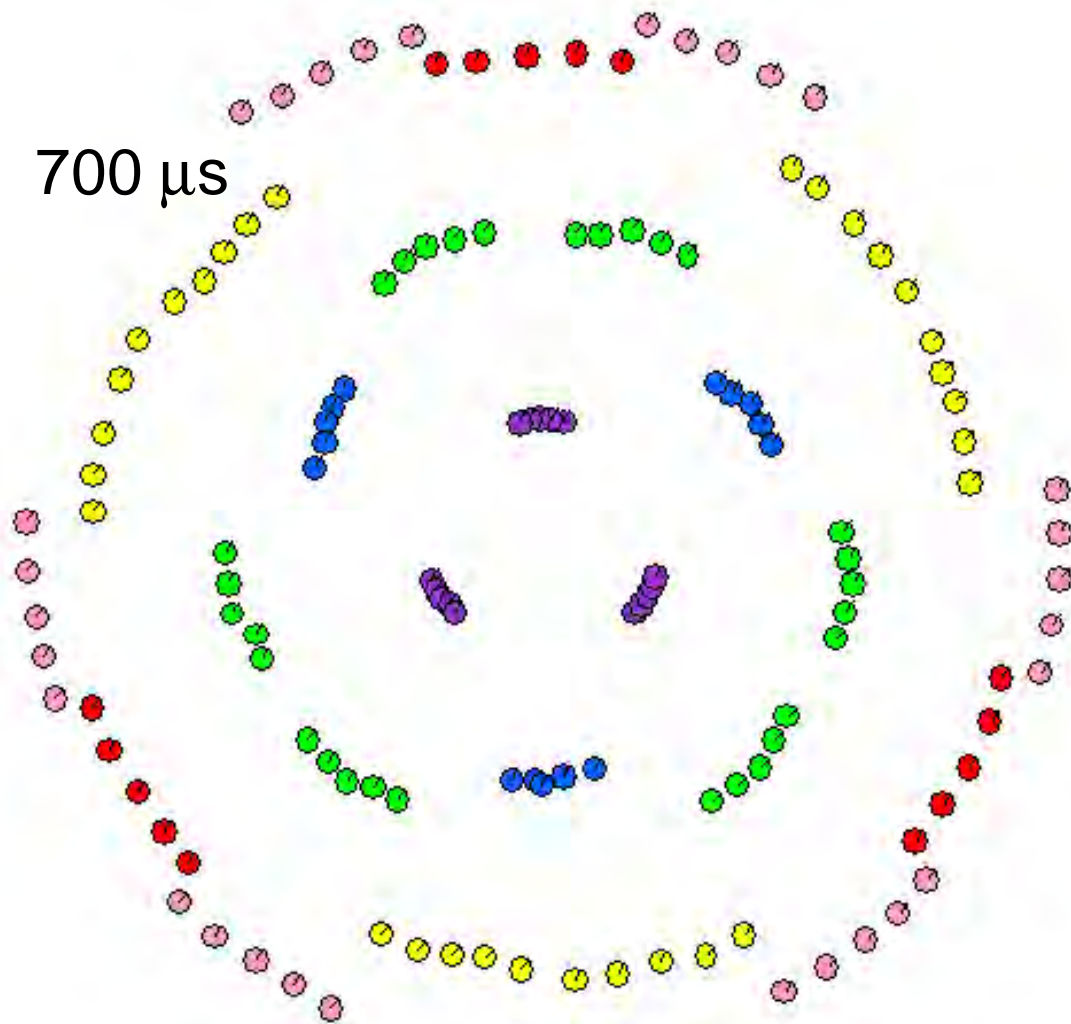


# 30 mm ABM Subprojectile Payload Ejection Dynamics

35 Subprojectiles at 1.5 g  
approx. 200 g Payload



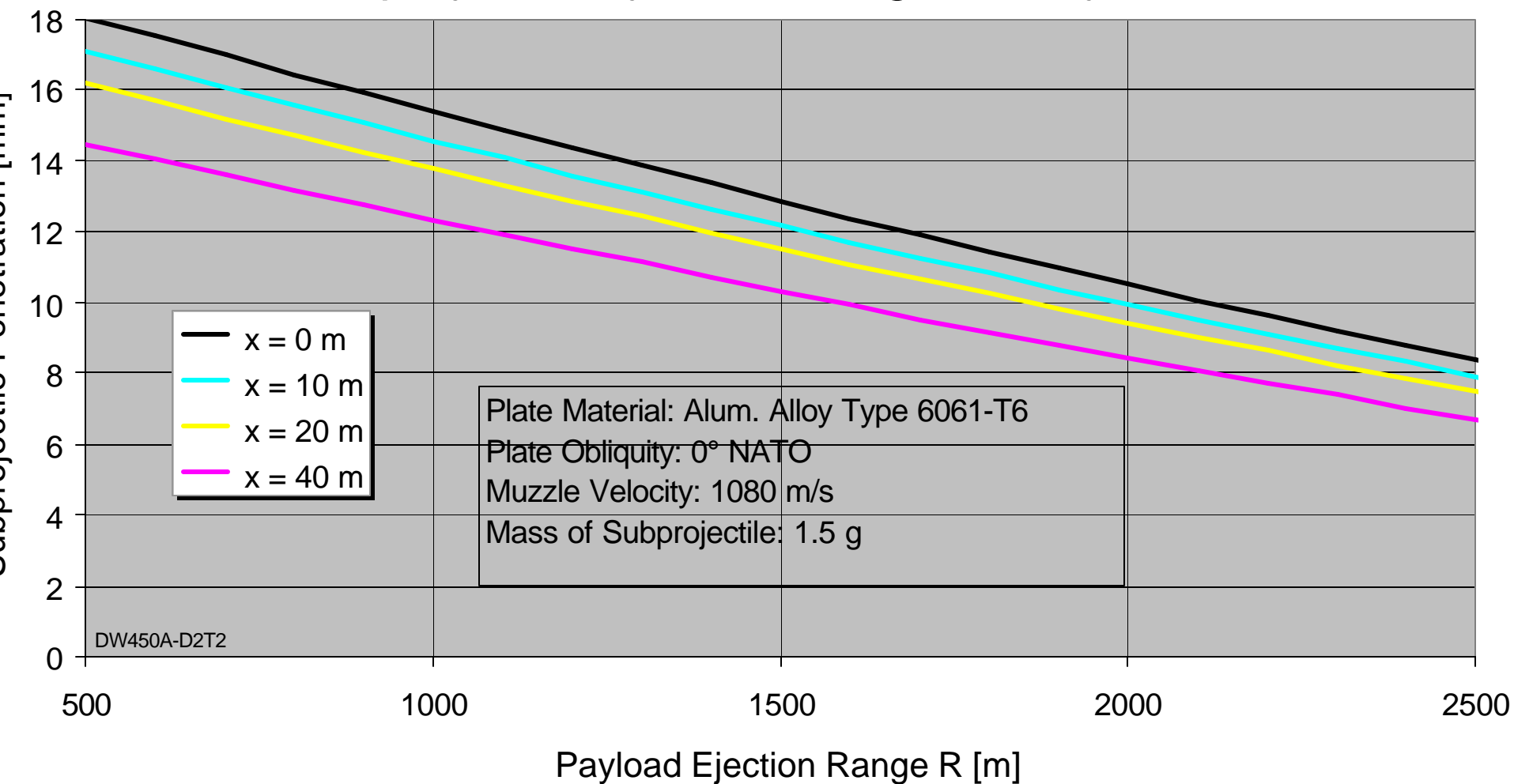
700  $\mu$ s





# BM Subprojectile Penetration

Parameters: Subprojectile Ejection Range R & Ejection Distance x



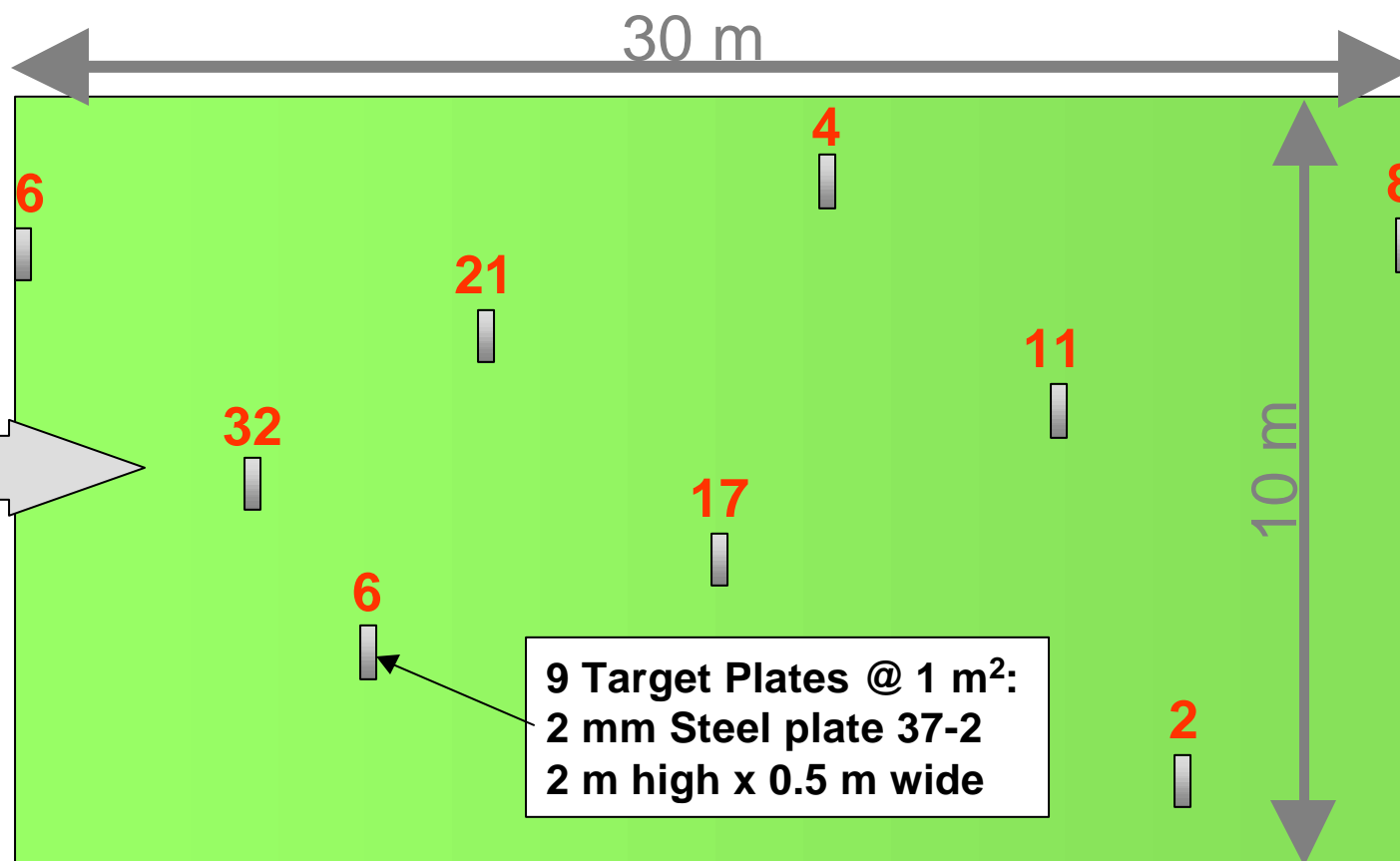
# BM 30 mm x 173

Effectiveness against ATGW-Bunker at 1 km



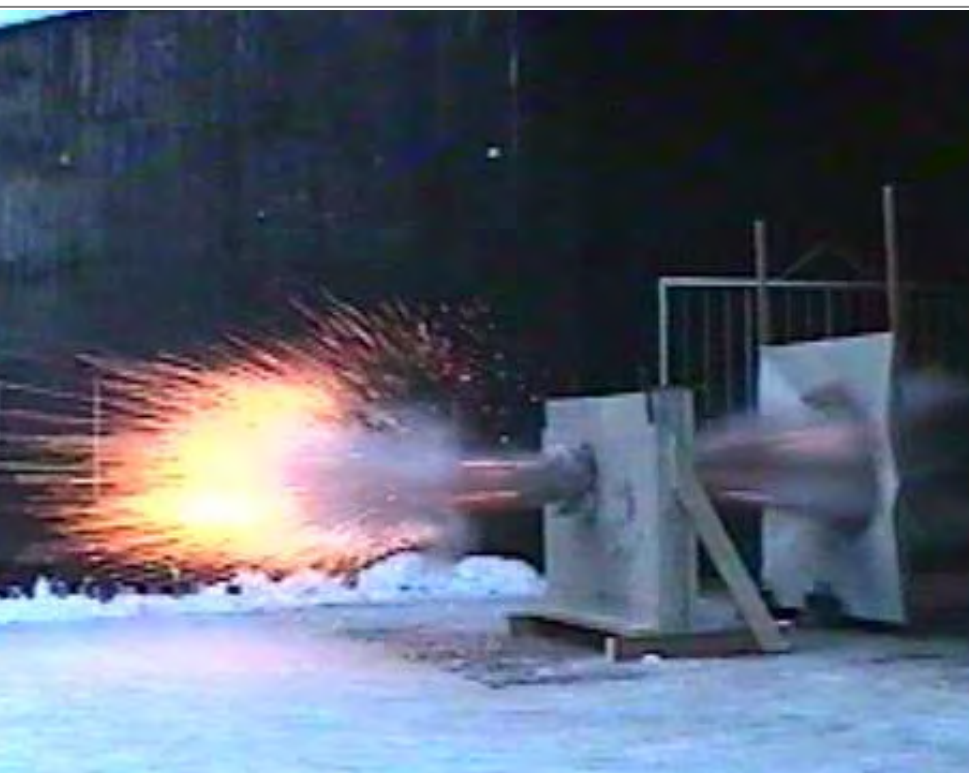
# ABM KETF 30mm x 173 against Squad of 9 at 1.2 km Range

**4 Rds @ 135 Subprojectiles = 540 SP**  
**Total: 107 Plate Perforations (~ 20%)**



# BM KETF 30mm x 173 against Urban Target (Unprogrammed Fuze)

Target: 20 cm Concrete Wall with double Steel-Structure Reinforced  
Results: Target Fully Penetrated





***Air Force***



**USAF**

Lt Col Jorge Garza  
HQ Air Force Security Forces Center  
“Combat Arms Center of Excellence”  
Lackland AFB, TX  
DSN 473-1206 Commercial (210) 671-1206





# NEW MISSION/TECHNOLOGIES



- **Air Force Frangible Munitions**
  - Only cost effective solution to environmental problems
    - Eliminates environmental, health, and most safety problems
    - Executive Order 12856, Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements do not exempt US Military services
  - Frangible currently approved for 9mm and 5.56mm only
    - Limited to training use only
    - Accuracy at 25 meters is indistinguishable between lead based and frangible
  - Air Force is currently interested in 12 gauge and 7.62mm frangible for use at 10 meter targets and increased accuracy at greater distances



## AREAS OF INTEREST



- Counter stand-off weapons and enemy forces in all weather conditions during day or night
- See around corners and out of defilade positions without exposure to enemy fire
- Rapidly locate, in real time, the origin of sniper/indirect enemy fire and counter this threat
- Engage enemy targets with improved accuracy, lethality, and at increased ranges with individual and crew served weapons
- Discriminate between friendly, enemy, and noncombatant personnel, in real time
- Directed energy weapons for non-lethal missions, such as laser, acoustic, pulse, microwave, etc



Lethality, Survivability, Mobility and  
Sustainment for America's Army



## ***JSSAPMC UPDATE***

### ***2002 NDIA INTERNATIONAL INFANTRY***

### ***AND***

### ***JOINT SERVICES SMALL ARMS SYMPOSIUM***

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**COL Michael Padgett, Commander CCAC**  
**Chairman JSSAP MC**  
**Phone: 973-724-7940**  
**Email: [mpadgett@pica.army.mil](mailto:mpadgett@pica.army.mil)**



# *JSSAPMC MISSION*

- Harmonize and Execute Joint RDT&E Projects
- Identify and Apply Technology Base
- Establish Joint Requirements
- Transition to PM's for SDD and Production
- Continue Development and Production Oversight
- Serve as Focal Point for Alliance Needs and Development



# ***JSSAPMC MEMBERSHIP***



## **Chairman**

COL Michael Padgett (Commander, CCAC)

**Army:**

Mr. F. Stone (USAIC)

**Marines:**

Mr. D. Hansen (MCSC)

**Air Force:**

LtCol J. Garza (HQ AFSF)

**Navy:**

Mr. J. Gaskill (NAVSEASYSCOM)

**Coast Guard:**

CAPT D. Deputy (HQ USCG)

**SOCOM:**

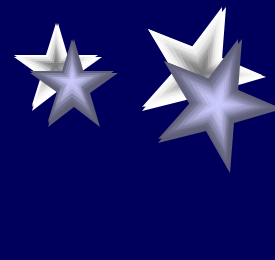
COL T. Spellissy (HQ SOCOM)

**Army PMSW**

LTC G. Z. Brown (PEO SOLDIER)

**JNLWD:**

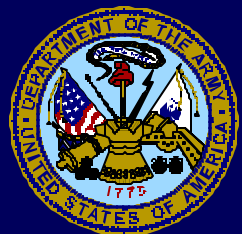
Mr. K. Swenson (JNLWD)







# *JOINT SERVICE SMALL ARMS MASTER PLAN (JSSAMP)*



- DoD Small Arms RDT&E Guide
- Small Arms Development and Fielding Strategy
- Key Fiscal Planning Document
- Congressionally Approved, June 1995
- 2nd Edition, 5 October 1998 MG Cosumano, Assist. DCSOPS, Force Development
- 3rd Edition draft in final review





# JOINT SERVICE SMALL ARMS ROADMAP





# ***JSSAPMC PROCEEDINGS***



- **Semi-Annual Meetings**
  - Service Needs Interchanges
  - Approve Annual Program (STO/ATD)
  - Requirements, Technical and Acquisition Interchanges
  - Conducted Non-Lethal Joint Shotgun Ammo Feasibility Tests.
- **Address Individual Service Needs**
  - Arranged USMC to USAF transfer of M16A2's and M9's.
  - Arranged USMC to Navy transfer of coded M60's.
  - Delivered Army/USMC M4 Training Materials to USAF.
  - Delivered Survey of Green 9mm Frangible Ammo to USCG.

# **NATIONAL SMALL ARMS CENTER**

**PRESENTED TO**

**NDIA 2002 INTERNATIONAL INFANTRY AND  
JOINT SERVICES SMALL ARMS SECTION SYMPOSIUM**

**ON**

**MAY 15, 2002**

**BY**

**DAROLD L. GRIFFIN  
ENGINEERING AND MANAGEMENT EXECUTIVES INC.  
ALEXANDRIA, VA 22504**

## **OUTLINE**

- **PURPOSE**
- **BACKGROUND**
- **SCOPE**
- **METHOD OF OPERATION**
- **KEY AREAS OF INTEREST**
- **PAYOFF**
- **SCHEDULE**



## **PURPOSE**

- **PRESENT OVERVIEW OF THE ARMY'S NATIONAL SMALL ARMS CENTER**
- **CENTER WILL SERVE:**
  - **US ARMY, NAVY, AIR FORCE AND MARINE CORPS**
  - **ACADEMIA**
  - **INDUSTRY**
- **WORLD CLASS CENTER ENGAGED IN TECHNOLOGY RESEARCH AND DEVELOPMENT, TECHNOLOGY TANSFER, AND AS AN INFORMATION RESOURCE**

## **BACKGROUND**

- **US SMALL ARMS TECHNOLOGY AND INDUSTRIAL BASE ARE THREATENED BY:**
  - **CHANGING NATIONAL PRIORTIES**
  - **DOWNSIZING AND RESTRUCTURING OF INDUSTRY AND GOVERNMENT**
  - **LOST VOICE IN DEFENSE BUDGET AND OTHER COUNSELS**
- **A STRONG PARTNERSHIP WITH ACADEMIA AND INDUSTRY WILL:**
  - **ADVANCE SMALL ARMS TECHNOLOGY NEEDS**
  - **HELP RETAIN THE US TECHNOLOGY BASE AND, IN TURN, SPUR INDUSTRY PRODUCTION**
  - **PROJECT A UNIFIED VOICE FOR SMALL ARMS COMMUNITY**
- **CENTERS ARE AN INTEGRAL PART OF THE ARMY'S TECHNOLOGY AND INDUSTRIAL BASE STRATEGY**

## **RATIONALE AND CONCEPT FOR CENTER**

- **CONDUCTED STUDY OVER PAST SIX MONTHS**
- **LOOKED AT HISTORY OF SMALL ARMS TECHNOLOGY AND INDUSTRIAL BASE**
  - **DECLINING FUNDING AND RECOGNITION**
  - **NEED FOR A TURN-AROUND MECHANISM**
- **STUDIED NEARLY 50 ON-GOING CENTERS**
- **RECOMMENDED A SUSTAINING CENTER**
  - **LOCATED AT TACOM - ARDEC**
  - **INDUSTRY AND ACADEMIA CONSORTIUM**
  - **LONG TERM CONTRACTUAL ARRANGEMENT**

## **NATIONAL SMALL ARMS CENTER SCOPE OF ACTIVITIES**

- **LIFE CYCLE SCIENCE AND ENGINEERING**
- **PROGRAMMATIC AREAS**
  - **RESEARCH**
  - **TECHNOLOGY DEVELOPMENT**
  - **PRODUCT AND PROCESS DEVELOPMENT**
  - **PRODUCT AND PROCESS IMPROVEMENTS**
  - **PRODUCTION ENGINEERING**
  - **MAINTENANCE ENGINEERING**
  - **TEST AND DEMILITARIZATION**

## **NATIONAL SMALL ARMS CENTER SCOPE OF ACTIVITIES (CONT'D)**

- **CORE END ITEMS**

- **HAND GUNS, SHOULDER FIRED WEAPONS, GRENADE LAUNCHERS, MACHINE GUNS, GRENADE MACHINE GUNS, AUTOMATIC CANNON AND OTHER GROUND WEAPONS / DEVICES (SUCH AS LIGHT WEIGHT ACOUSTIC AND DIRECTED ENERGY WEAPONS)**
- **SMALL ARMS AMMUNITION OF ALL TYPES**
- **HAND, GUN LAUNCHED AND ROCKET GRENADES**
- **FIRE CONTROL, EMBEDDED COMPUTERS AND POWER SUPPLIES**
- **GUN MOUNTS**
- **FUZING**



## **NATIONAL SMALL ARMS CENTER CAPABILITIES**

- **CRITICAL MASS OF SCIENTISTS, ENGINEERS AND SUPPORTING PERSONNEL**
- **FACILITIES FOR SIMULATION AND MODELING; RAPID PROTOTYPING; ENERGETICS FORMULATION; LOAD, ASSEMBLE AND PACK OF AMMUNITION; DYNAMIC AND FIXED RANGES; EXPERIMENTAL RANGES FOR WARHEADS, HIGH PERFORMANCE COMPUTER ACCESS AND CHEMICAL, PHYSICAL AND METALLURGICAL LABORATORY ANALYSES**
- **REAL-TIME NETWORK TO GOVERNMENT AND MEMBER TEST RANGES**
- **DATA REPOSITORY AND RETRIEVAL RESOURCES**
- **CONSULTATION AND ADVISORY SERVICES**
- **EDUCATION AND TRAINING CAPABILITIES**

## **NATIONAL SMALL ARMS CENTER METHOD OF OPERATION**

- **MAINTENANCE AND OPERATION OF THE CENTER WILL BE THE RESPONSIBILITY OF ARDEC**
- **RESEARCH AND DEVELOPMENT WILL BE CONDUCTED BY A CONSORTIUM OF INDUSTRY AND ACADEMIA AS THE RESEARCH ARM OF THE CENTER**
- **THE GOVERNMENT WILL CONTRACT WITH THE CONSORTIUM USING A SECTION 845 “OTHER TRANSACTION AGREEMENT(OTA)” (10 USC 2371)**
  - **EXEMPT FROM MOST ACQUISITION LAWS AND REGULATIONS**
  - **PERMITS COMERCIAL RELATIONSHIP**
  - **ALLOWS CO-FUNDING AND PAYMENT OF PROFIT**
  - **CONTROLLED BY A GRANTS OFFICER**

## **NATIONAL SMALL ARMS CENTER METHOD OF OPERATION (CONT'D)**

- **CONSORTIUM MEMBERS WILL BE BOUND BY A CONSORTIUM MANAGEMENT AGREEMENT OR SIMILAR DOCUMENT**
  - **DEVELOPED BY THE MEMBERS**
- **OPEN RELATIONSHIP BETWEEN GOVERNMENT AND CONSORTIUM**
  - **GOVERNMENT WILL PROVIDE OBJECTIVES AND REQUIREMENTS AT LEAST ANNUALLY**
  - **CONSORTIUM MEMBERS WILL OFFER TECHNICAL SOLUTIONS THROUGH TECHNICAL COMMITTEES**
  - **GOVERNMENT WILL DEVELOP ROAD MAPS, MASTER PLAN, BUDGET AND ANNUAL PLAN OF EXECUTION BASED IN PART OR WHOLE ON THE CONSORTIUM INPUT**
- **AN ANNUAL BAA WILL ANNOUNCE TECHNICAL PROGRAMS TO BE ACQUIRED AND SOURCE SELECTION CRITERIA**

## **NATIONAL SMALL ARMS CENTER METHOD OF OPERATION (CONT'D)**

- **PROGRAM EXECUTION WILL BE ACCOMPLISHED BY CUSTOMARY PROGRAM / PROJECT MANAGEMENT METHODS**
  - **CUSTOMERS OUTSIDE ARDEC MAY MANAGE THEIR RESPECTIVE PROGRAMS AND PROJECTS**
- **THE CENTER WILL HAVE A FULL TIME TECHNICAL DIRECTOR**
- **THE CONSORTIUM WILL HAVE A FULL OR PART TIME ADMINISTRATIVE DIRECTOR**
- **THE OTA AGREEMENT IS EXPECTED TO RUN FOR 5 YEARS AND BE RENEWABLE FOR AN ADDITIONAL 5 YEAR TERM**

## **PAYOFF FOR INDUSTRY AND ACADEMIA**

- **BETTER UNDERSTANDING OF GOVERNMENT NEEDS AND PLANS**
- **OPPORTUNITY TO INFLUENCE CONTENT AND PRIORITIES OF ARMY'S RESEARCH AND DEVELOPMENT PROGRAM**
- **COLLABORATION AMONG MEMBERS AND GOVERNMENT**
- **COMPETITION FOR RESEARCH FUNDING LIMITED TO CENTER MEMBERS**
- **SIGNIFICANT INCREASES IN FUNDING FOR RESEARCH AND DEVELOPMENT AND FOLLOW-ON PRODUCTION**
- **TECHNOLOGIES TO REACH PRODUCTION MORE QUICKLY**

## **PAYOFF FOR ARMY**

- **STRONG, LONG TERM RELATIONSHIP WITH INDUSTRY AND ACADEMIA**
- **CRITICAL MASS OF SCIENTISTS AND ENGINEERS**
- **ACCELERATED RESEARCH AND DEVELOPMENT**
- **POTENTIAL FOR COST SHARING ON SPECIFIC PROGRAMS**
  - **GOVERNMENT / INDUSTRY**
- **SUPERIOR PROGRAMS AND PRODUCTS FOR WARFIGHTERS AND HOMELAND DEFENSE**
- **GROWTH IN TECHNOLOGY AND INDUSTRIAL BASE**



## **NATIONAL SMALL ARMS CENTER MILESTONES**

<b><u>TASK</u></b>	<b><u>EST COMP DATE</u></b>
• <b>APPROVAL OF NATIONAL SMALL ARMS CENTER CONCEPT</b>	<b>31 MAY 2002</b>
• <b>PUBLISH BAA ANNOUNCING INDUSTRY DAY AND REQUESTING SHOW OF INTEREST</b>	<b>14 JUN 2002</b>
• <b>INDUSTRY DAY</b>	<b>16 JUL 2002</b>
• <b>INDUSTRY DAY II (IF NECESSARY) TO RESOLVE ISSUES, OBTAIN MEMBERSHIP PLEDGES</b>	<b>14 AUG 2002</b>
• <b>DRAFT AND COORDINATE OTHER TRANSACTION AGREEMENT AND CONSORTIUM MEMBER AGREEMENT</b>	<b>15 NOV 2002</b>

**NATIONAL SMALL ARMS CENTER  
MILESTONES (CONT'D)**

<b><u>TASK</u></b>	<b><u>EST COMPL DATE</u></b>
• <b>SUBMIT DRAFT OTHER TRANSACTION AND CONSORTIUM MEMBER AGREEMENTS TO REGULATORS (FTC &amp; DOJ)</b>	<b>22 NOV 2002</b>
• <b>COMPLETE COORDINATION AND REGULATORY REVIEWS OF AGREEMENTS</b>	<b>3 DEC 2002</b>
• <b>INDUSTRY AND ACADEMIA SIGN CONSORTIUM MEMBER AGREEMENT, CENTER IS OPENED</b>	<b>8 JAN 2003</b>
• <b>OTHER TRANSACTION AGREEMENT SIGNED WHEN FUNDS ARE RECEIVED</b>	<b>TBD</b>



# Marine Corps Systems Command

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**National Defense Industrial Association**

**Joint Services Small Arms Section**

**Annual Conference**

*Mr. Dave Hansen*



# INFANTRY WEAPONS SYSTEMS

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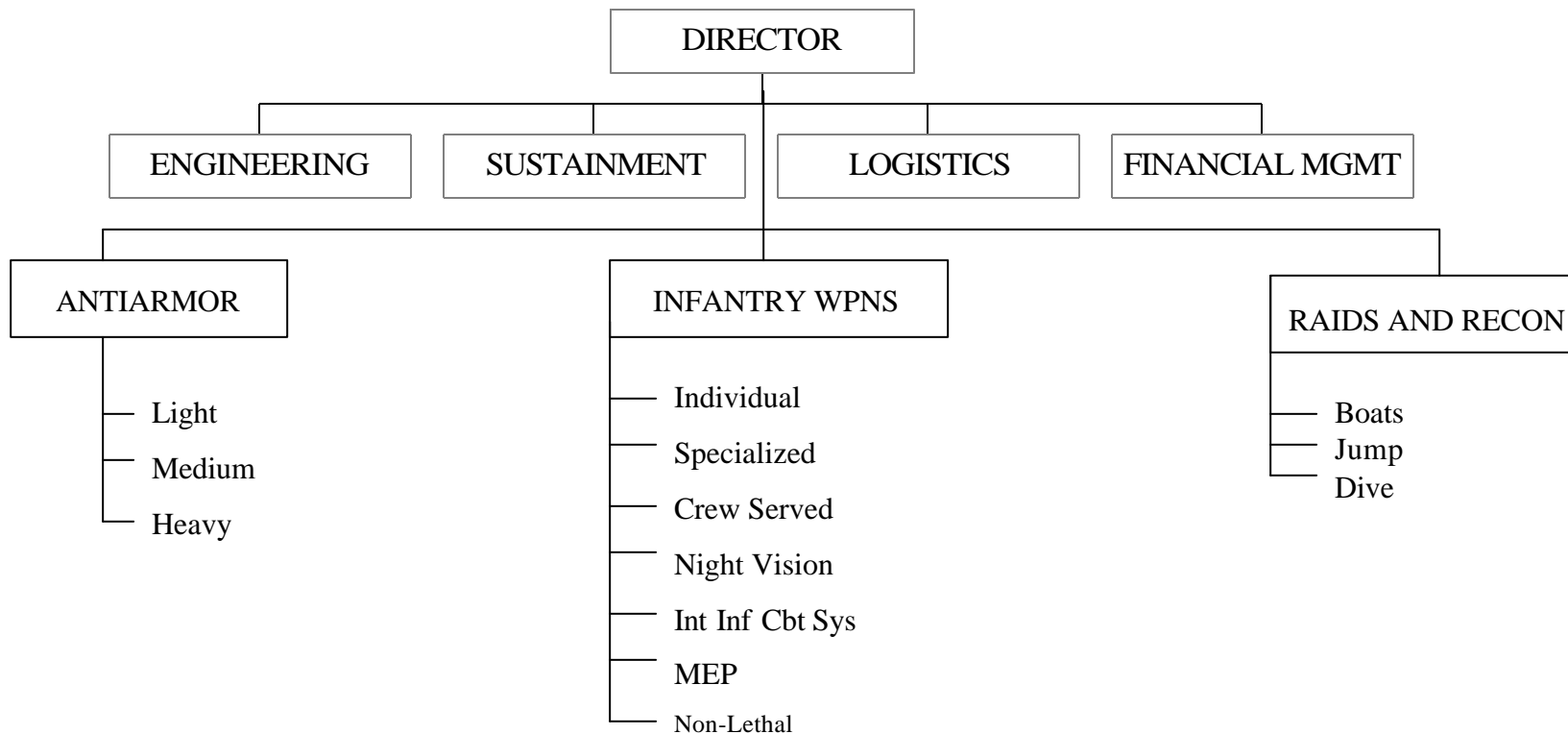


## MISSION

**Plan for and execute the approved programs for all Research, Development, Acquisition, Fielding, and Life Cycle Support for assigned equipment and weapon systems**



# INFANTRY WEAPONS SYSTEMS





# **INFANTRY WEAPONS SYSTEMS PRODUCT GROUP - DIRECTORATE**



## **Overall goals**

- **Rebuild readiness**
- **Assist in Determination of requirements to improve capability and lethality**
  - \* **Infantry Weapons (Small Arms, Mortars)**
  - \* **Night Vision (Night/Day Optics, Lasers)**
  - \* **Non-Lethal**
- **Areas of industry interest**
  - \* **Mortars**
  - \* **Modular Weapons System (free float rail system, optics, weapon enhancements)**
  - \* **Improvements: e.g., laser coatings on optics; camouflaged weaponry, light weight tripods, extended life machine gun barrels, M203 replacement, air-bursting/proximity fuzes for low velocity 40mm grenades, automatic rifles for the inf squads, flash hiders and suppressors, slings and spare barrel bags**
  - \* **Optics: Sniper Rifle Scope replacement, Rifle Combat Optic, Fusion devices**
  - \* **Non-Lethal: Shotgun ammo (cycle M1014)**





# Marine Corps Systems Command

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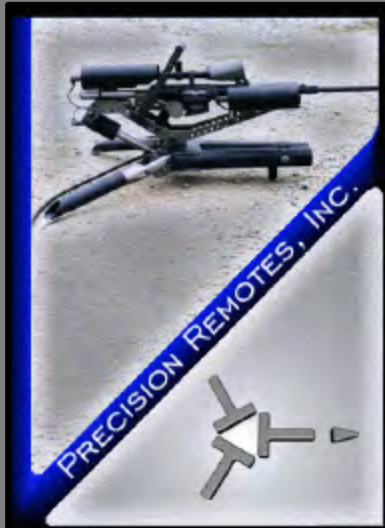
## Means of Contact

**Mr. Dave Hansen**

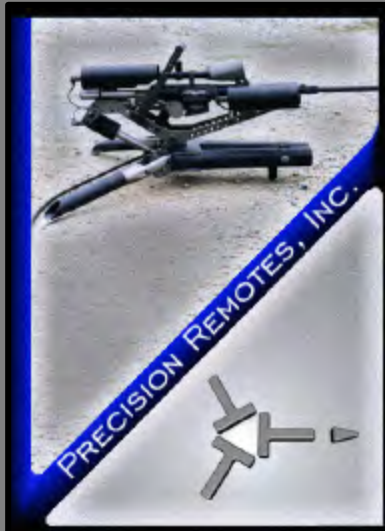
**PM-Infantry Wpns**

**(703) 784-2006, ext 2747**

**[hansendk@mcsc.usmc.mil](mailto:hansendk@mcsc.usmc.mil)**



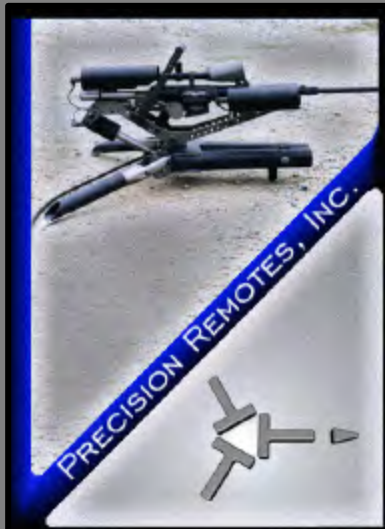
**These slides are in  
support of an oral presentation  
given by Graham Hawkes**



# 25 YEARS OF SOLUTIONS

## For

# DANGEROUS DUTIES




# DEEP ROVER™



# DEEP FLIGHT 502™



Photo:   
H.O.T.

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# PRECISION REMOTES, INC.



Photo: Precision Remotes, Inc.


## T-2

## TRAP T-2<sup>TM</sup>



# PRECISION REMOTES, INC.

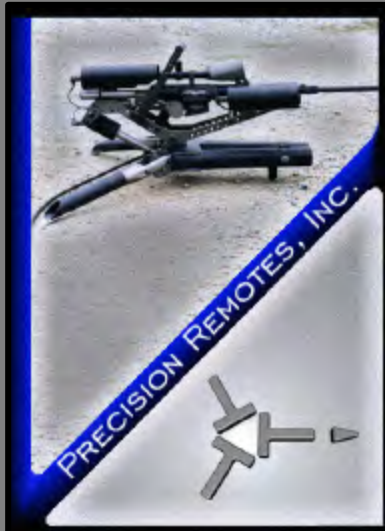


Photo:  Precision Remotes, Inc.

## T-250

## TRAP T-250<sup>TM</sup>

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# Current APPLICATIONS

- FACILITIES SECURITY
- (NETWORKED SECURITY SYSTEMS)
- REMOTE OBSERVATION POST
- USMC- SHIP/EMBASSY/OTHER
- USAF- EXPLOSIVE ORDNANCE DISPOSAL
- REMOTE SNIPER-OBS. POST



# PRECISION REMOTES, INC.



Photo: Precision Remotes, Inc.

FS

## TRAP T2-FS™

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# PRECISION REMOTES, INC.



## TRAP T-2 FS<sup>TM</sup>

# PRECISION REMOTES, INC.



## TRAP T-2 FS<sup>TM</sup>






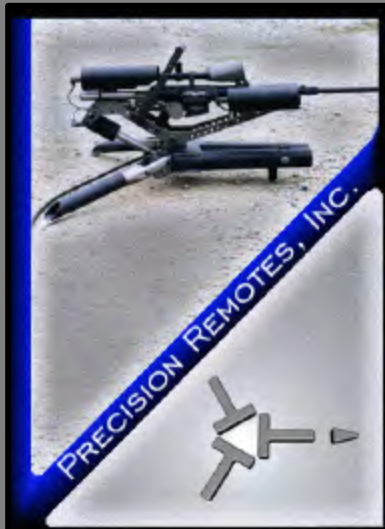
# TRAP O2-200<sup>TM</sup>

w/ DAVRO<sup>TM</sup> LENS




Photo:  Precision Remotes, Inc





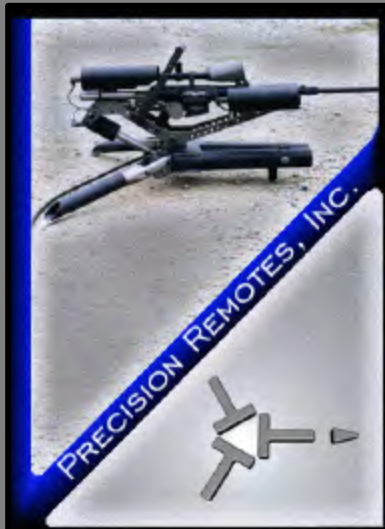
Weight: 6 lbs

Payload: 35 lbs

Photo:  Precision Remotes, Inc

# TRAP O1-100<sup>TM</sup>





Weight: 6 lbs / Payload: 35 lbs





USMC




Photos:  Precision Remotes, Inc



Photo: Precision Remotes, Inc.

USAF  
EOD

**T-250: .50cal. w/ M82-A1**



**Mk 19 1000 lbs**

**EOD**

**PUTLOS GERMANY**

Photos: Precision Remotes, Inc


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TRAP T-2™ 5.56mm

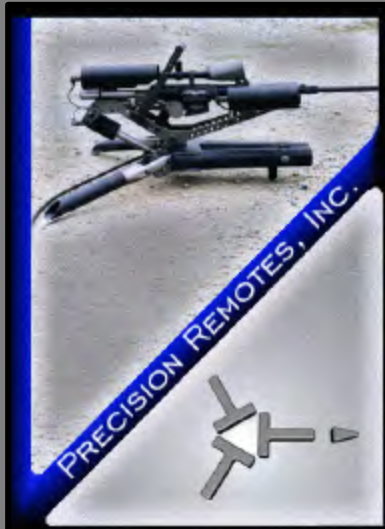


Photo:  Precision Remotes, Inc

# REMOTE SNIPER OBSERVATION POST

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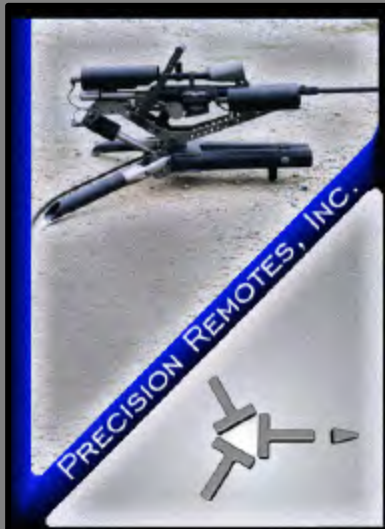


# FUTURE POSSIBILITIES

**AFTER 100 years**

**A RETURN TO**

**THE LETHALITY OF ACCURACY**



# COMBAT ACCURACY

## WEAPONS:

Benched ASSAULT RIFLE = 1 moa

Benched SNIPER RIFLE =  $\frac{1}{2}$  moa

## RANGE CONDITIONS:

SNIPER = 1 moa

TRAP = 1 moa



# UNDER FIRE

## PERFORMANCE

SOLDIER:

(Snap Shot est. less than 1 sec)=100moa

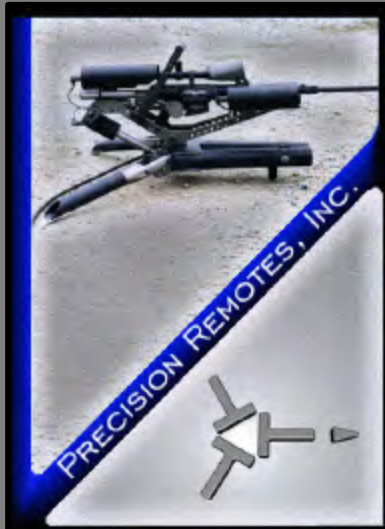
SOLDIER+TRAP +assault rifle

(less than 1 sec) = 3 moa

## REQUIREMENTS

ACCURACY REQUIRED est. = 5moa

TIME REQUIRED est. less than = 1.5 sec

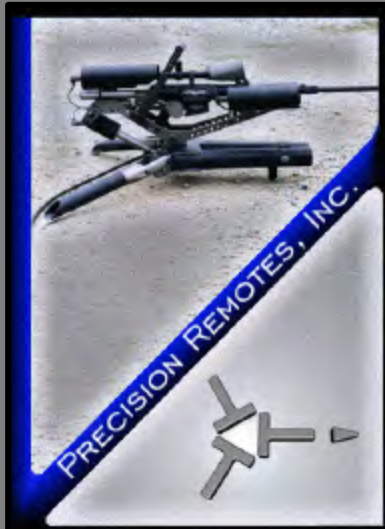


# PROBABILITY UNDER FIRE

SOLDIER 1:400

SOLDIER + TRAP (close to) 1:1

Note : All above assume combat range of 100yds. All estimates involving soldier performance are approximate.



# CRITICAL ISSUE

NET ZERO WEIGHT ?



# WEIGHT

Crew served M2	92 lbs (est.)
1000 ROUNDS AMUNITION	<u>250lbs (est.)</u>
Total =	342lbs

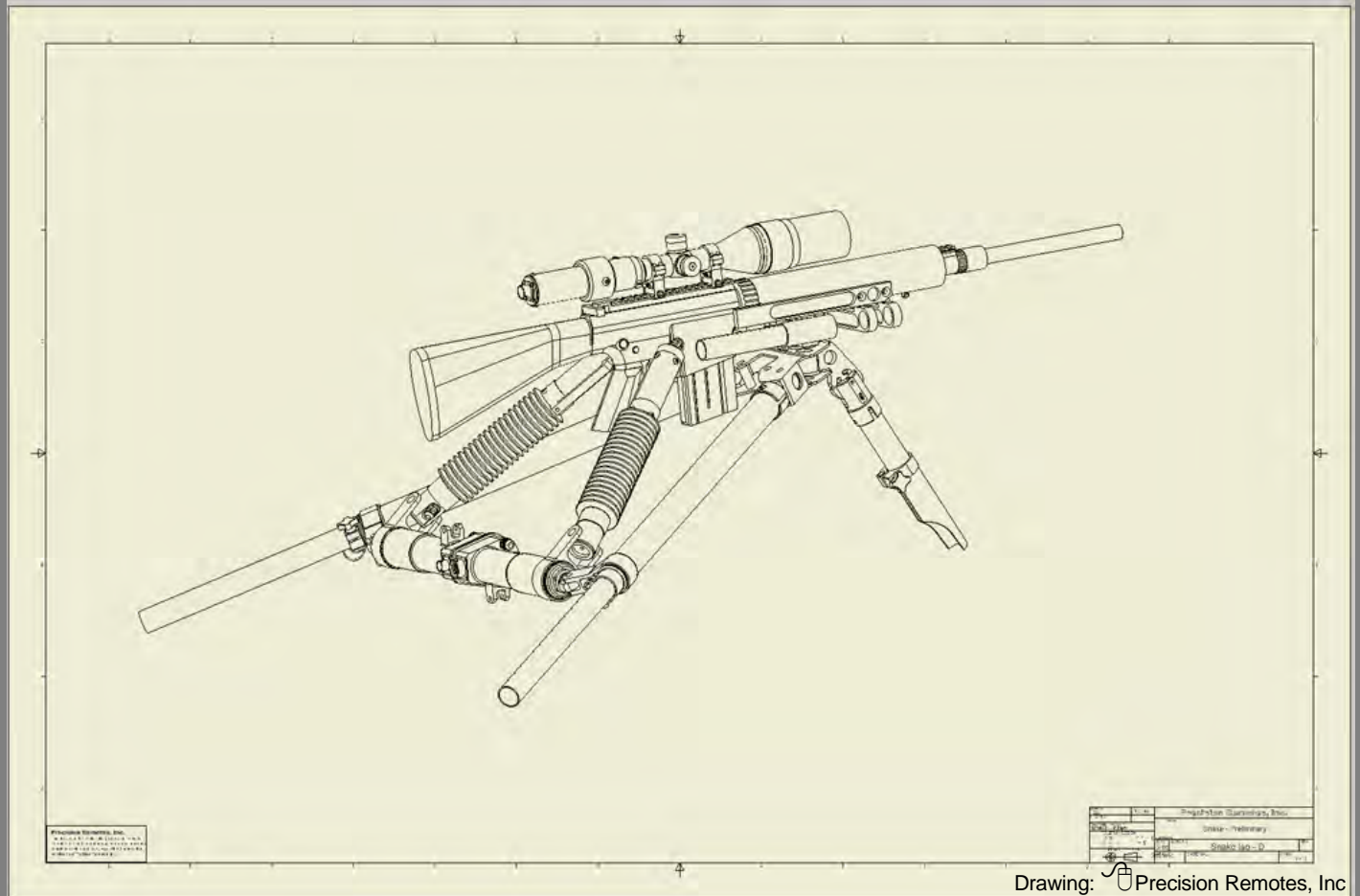
**TRADE FULLY AUTOMATIC 50cal. FIRE POWER  
for  
ONE ROUND ONE KILL LETHALITY**

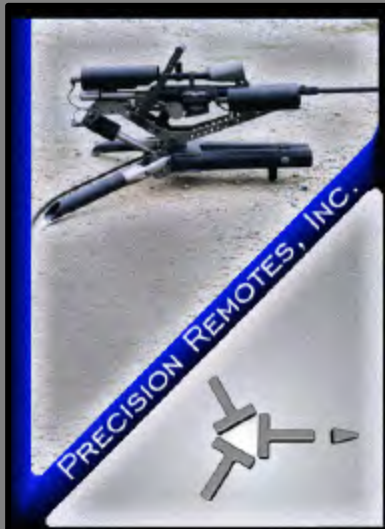
BARRETT M82-A1	42lbs (est.)
100 ROUNDS	25lbs (est.)
REMOTE SYSTEM	<u>15lbs (est.)</u>
Total :	82lbs





# SNAKE™



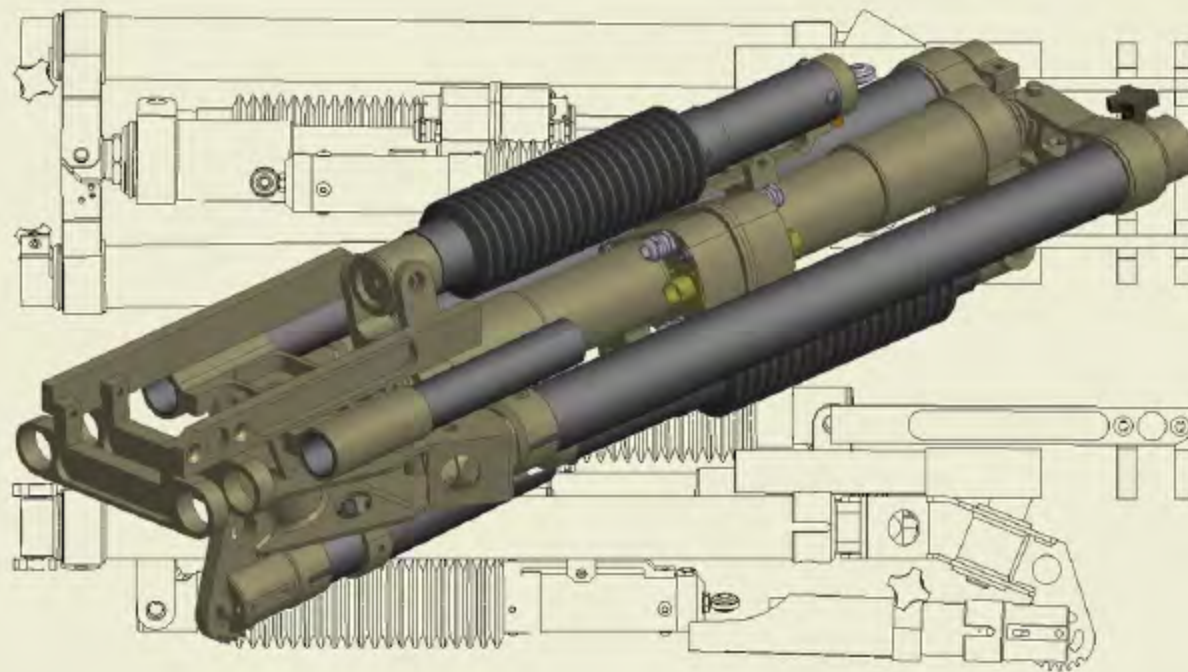


# SNAKE<sup>TM</sup> SR25




Drawing:  Precision Remotes, Inc

# SNAKE<sup>TM</sup> FOLDED



**8\*6\*27 ins. 15lbs**

Drawing:  Precision Remotes, Inc



END

# Moving Weapons Platform Simulator (MWEPS II)

Presented by

Dawn Hoffa

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(812) 854-4790



16 May 2002

# Overview

- Engineering Need
- Training Need
- MWEPS II Description
- Virtual Target Gunnery System (VTAGS)
- Summary



# Engineering Need

## ■ Crew Served Platforms

- Less costly/subjective performance rating is needed

## ■ Stabilized Remote Operated Platforms

- More testing time is required for more complex platforms
- Quantitative data is required to determine performance
- Realistic specifications need to be determined

VIDEO

# Training Need

- More “Weapons Free” opportunities are needed
- Training for night situations is required
- Training for various sea state conditions is required

# MWEPS II Description

- Provide Engineering Test and Training Platform for Small Arms, Mounts and EO Sensors
  - Motion base platform
  - Computer generated scenario on a large screen
  - Engagement of targets for training
  - Engineering feedback collection
  - Live fire engineering test compliment
  - Scarce training range time supplement
  - Performance model for future acquisition/development creation

# MWEPS II Description



Existing MWEPS I Platform

Fleet Training Center, Dam Neck, VA

# MWEPS II Description

Visual Presentation Screen



MK V Special  
Operations Craft

Motion Base Platform



# MWEPS II Description

## Motion Platform and Software

- 6 Degree of Freedom Motion Platform
- 5000 lb. Payload
- 18 inch stroke length, 30 deg/sec rotational velocity
- Electromechanical Actuators
- Electric Servomotors
- Digital Motor Controls
- Motion Control Electronics Box
- Modified Vendor Motion Platform Software



# MWEPS II Description

## Virtual Environment and Software



- Large Display Screen
- VEGA Marine Software models open ocean scenario

# MWEPS II Description

## Virtual Targets and Software



- Government generated craft models
- 3 position buoyancy model controls craft motion in response to environment

# MWEPS II Description

## Tracker and Software

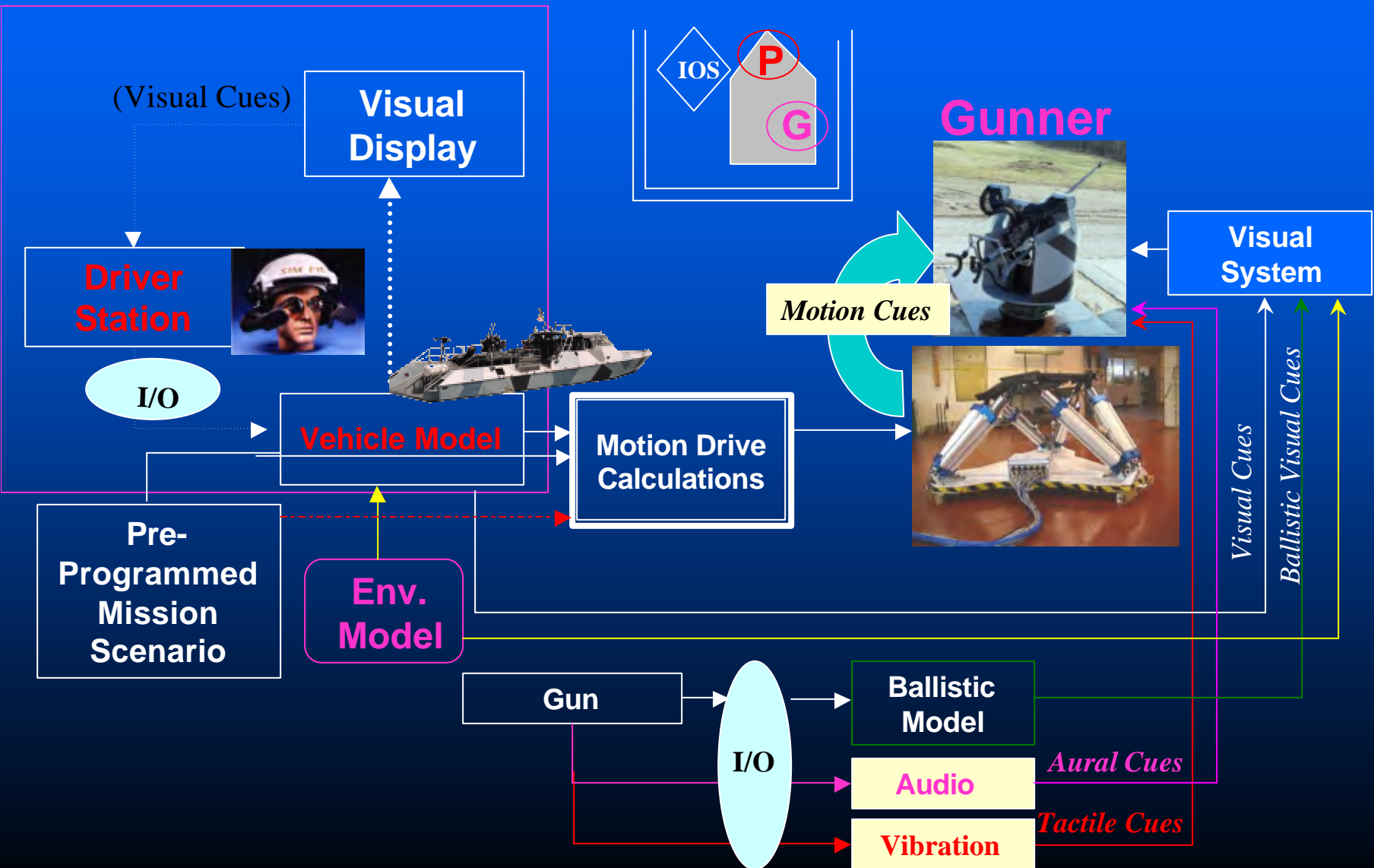
- Gun positional infrared locator
- Screen positional optical tracker
- Motion platform positional indicator
- Computer generated bullet trajectory
- Hit or splash model
- Government generated software to determine performance

# MWEPS II Description

## Repeatable Simulation Scenario

- Open ocean environment
- Single inbound threat
- Engage hostile target
- Evasive maneuver to break aim point
- Reengage hostile target
- Score hit, miss and aiming criteria

# MWEPS II Description





# MWEPS II Description

## Future Development

### ■ Additional Craft & Weapons

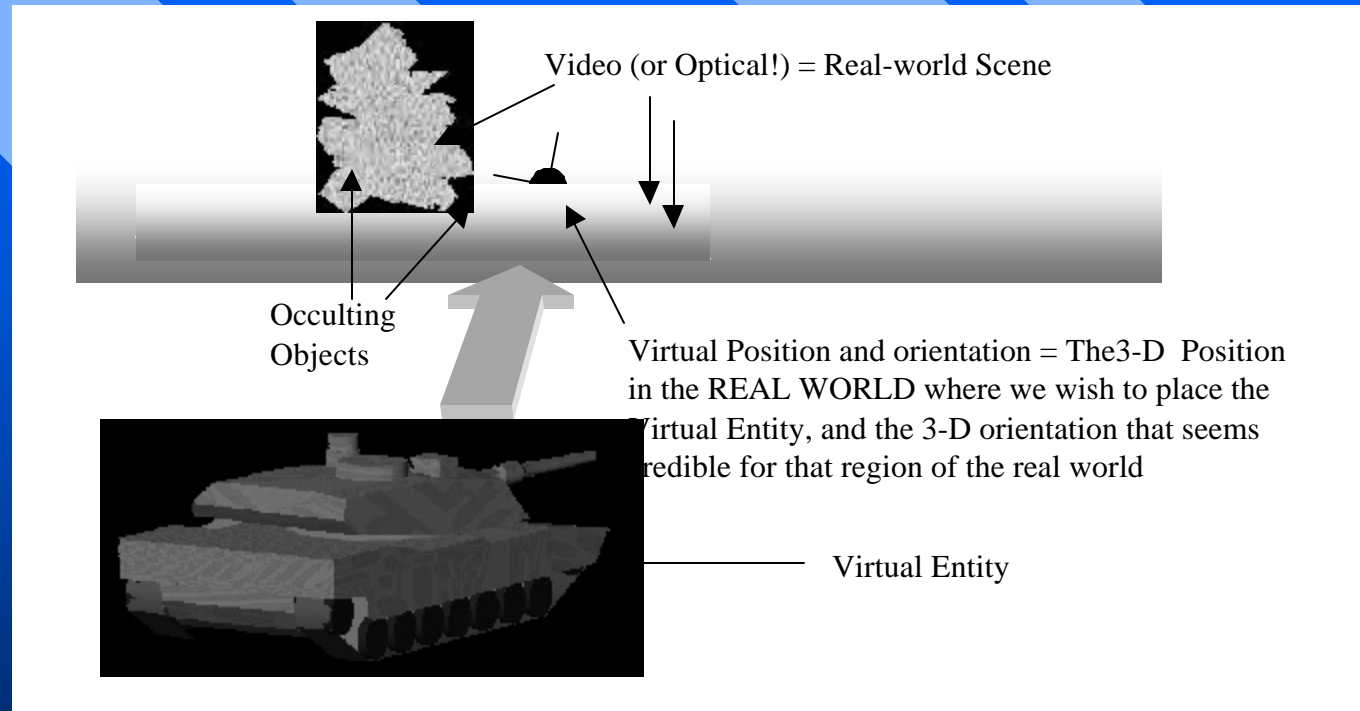
- Rotary Wing - NAVAIR
- Vehicles - USASOC, USMC
- Fleet Assets



### ■ Mission Level Scenarios

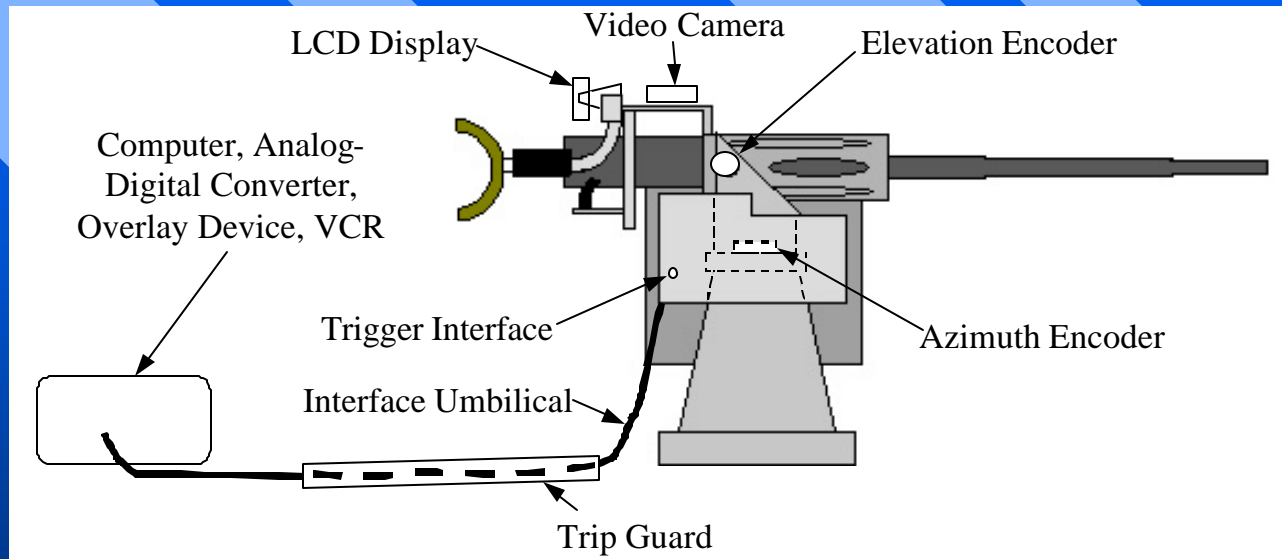
- Increased Visual Presentation
- Involve More Training Participants
- More Scenarios
- Connectivity to Other Simulators

# Virtual Target Gunnery System (VTAGS)



- Permits gunner to engage virtual targets superimposed onto view screen
- Can be used w/ live fire or can generate simulated fire
- Gives quantitative data to determine performance

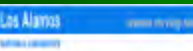
# Virtual Target Gunnery System (VTAGS)



- Easily mountable virtual training aid
- Used with weapon systems presently installed on maritime platforms
- Selectable scenarios that are skill dependant

# Summary

- MWEPS II is needed for engineering
- MWEPS II is needed for training
- MWEPS II can fulfill both of these needs on land
- VTAGS can fulfill the training needs at sea and is easily installed on existing maritime platforms



# *The Challenges of a Green Primer*

Presented by:

**Hugh A. Huntzinger**  
*TACOM-ARDEC*

In association with:

**Sung Kim**  
*NSWC-CRANE*



# Green Ammunition

## Target Materials



### VOCs

Primer Pocket Sealant  
Lacquer Thinner MEK  
Xylene MIK  
Toluene

### ODCs

Casemouth Sealant  
Methyl Chloroform

### VOCs

Blank Ctg Tip Sealant  
Ethyl Acetate Toluene  
MEK Xylene  
MIK

### HEAVY METALS

Primer Compositions  
Lead Styphnate  
Barium Nitrate  
Antimony Sulfide

### VOCs

Combat Ctg Tip ID  
Glycol

### HEAVY METALS

Projectile Slug  
Lead\Antimony

## Tracer & Ignitor Compositions

### VOCs

Ethyl Alcohol

### HEAVY METALS

Barium Peroxide  
Lead Dioxide  
Barium Nitrate

### ODCs

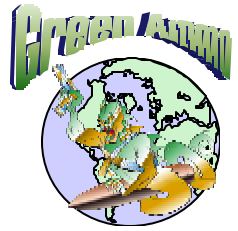
Methyl Chloroform

*Committed to Excellence*





# Joint Working Group for Non-Toxic Ammunition



## CHAIR – TACOM-ARDEC

Naval Surface Warfare Center – Crane  
Naval Air Warfare Center - China Lake  
Naval Surface Warfare Center - Indian Head  
Air Force- AFCEE  
Air Force - Randolph AFB  
Marine Corps System Command- Arlington  
Coast Guard HQ-Washington  
National Guard HQ- Arlington  
USAIC- Ft. Benning  
US Army Reserve Command  
Army Center for Health Promotion &  
Prevention Medicine  
Naval Special Warfare - Coronado  
Ft Dix Force Projection  
Army Environmental Center- Edgewood  
Army Training & Support Center- Ft. Eustis

Industrial Operations Command  
Lake City Army Ammunition Plant



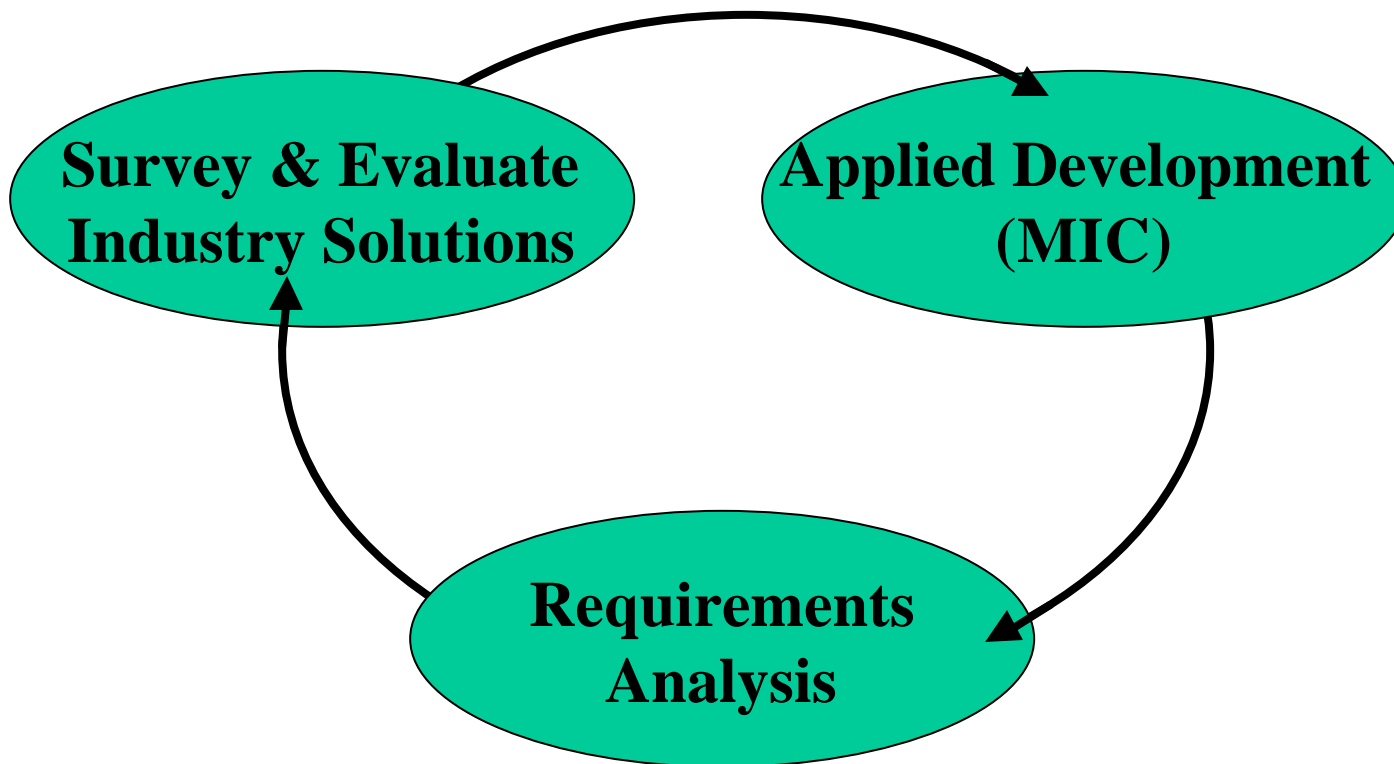
DOE- Oak Ridge National Lab  
DOE- Los Alamos National Lab  
DOE- Kansas City Plant  
Federal Bureau of Investigation  
Federal Law Enforcement  
Training Center

**Formed by ARDEC in October 1995**

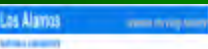
*Committed to Excellence*



# Green Primer Replacement Effort Technical Approach



*Committed to Excellence*



# Expected DoD Benefit



- **Projected FY01 - FY03 Heavy Metals Usage for Small Caliber Primers (Avg: 335 M Rounds)**

- Lead Styphanate: 25,106 lbs
- Barium Nitrate: 22,928 lbs
- Antimony Sulfide: 9,410 lbs

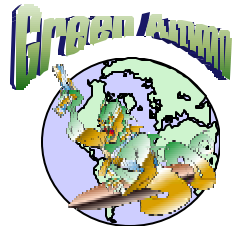
**28+ Tons of Heavy Metal Materials**

- **Current Process is Labor Intensive & Multi-Stepped**
  - MIC Process is expected to lend itself to Automation
- **Technology will leverage into Larger Calibers**
  - Lead Styphanate Based Variants



# Green Primer Replacement Effort

## Functional Requirements

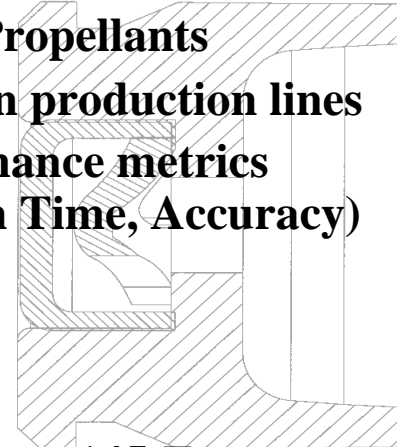


### Basic Design Objective

- “Drop In” replacement for existing primer
  - Compatible with current Propellants
  - Identification of impacts on production lines
  - No change in User performance metrics (Velocity, Pressure, Action Time, Accuracy)

### Key Technical Performance Metrics

- Environmental Extremes:
  - Storage/Transport: -65°F to +145°F
  - Operational: -65°F to +160°F
- Action Time:
  - Max Individual <2.5 mSec.  
(MIL-P-46610; MIL-P-3984)
- Ignition Sensitivity:
  - “All Fire”: 12 inches
  - “No Fire”: 3 inches



SECTION A-A  
SCALE 10.000

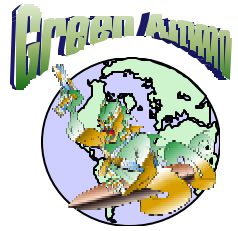
PRIMER NO. 41

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# Green Primer Replacement Effort

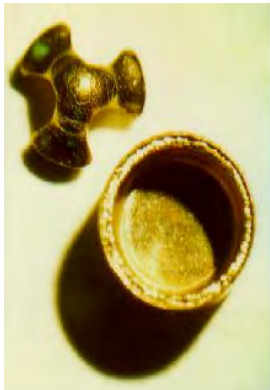
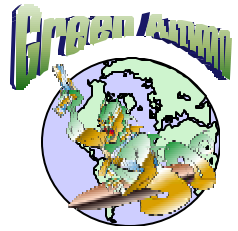
## COTS Industry Solutions



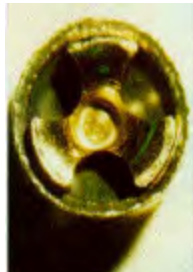
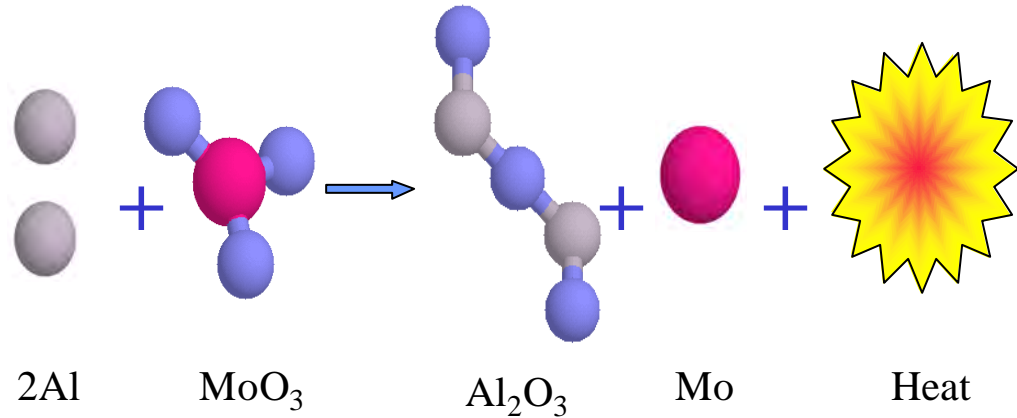
- Prior to FY96 - Services had initiated in-house efforts based on tightening Environmental Regulations
  - Duplication of effort between services
  - Evaluation Process not firmly Structured or Coordinated
- Several potential contenders were investigated, to varying depths. Key performance shortcomings included:
  - Insufficient extreme cold temperature performance
  - Hydroscopicity
  - Primer Sensitivity concerns
- FY96 - JWG Formed; first joint MIC R&D effort initiated



# Green Primer Replacement Effort Metastable Intermolecular Composites (MIC)



5.56 mm primer cup & anvil



MIC-loaded 5.56mm primer

- ✓ **New Family of Highly Energetic Materials**
- ✓ **Tailored from Joint DoD\DoE Development Program**
- ✓ **Function Not Effected by Temperature**
- ✓ **Resistant to Water Degradation**

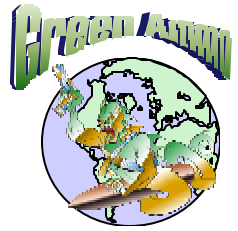
*Committed to Excellence*







# Green Primer Replacement Effort



## METASTABLE INTERMOLECULAR COMPOSITES

### MIC Accomplishments

- Joint Working Group for MIC Formed
- Demonstrated transfer of technology from DOE
- MIC Laboratory established at ARDEC
- Demonstrated methods of standardized characterization
- Supported NSWC with equipment and characterization
- Scaled-up LANL reactor output
- Technology Transfer to Industry of  $\text{MoO}_3$

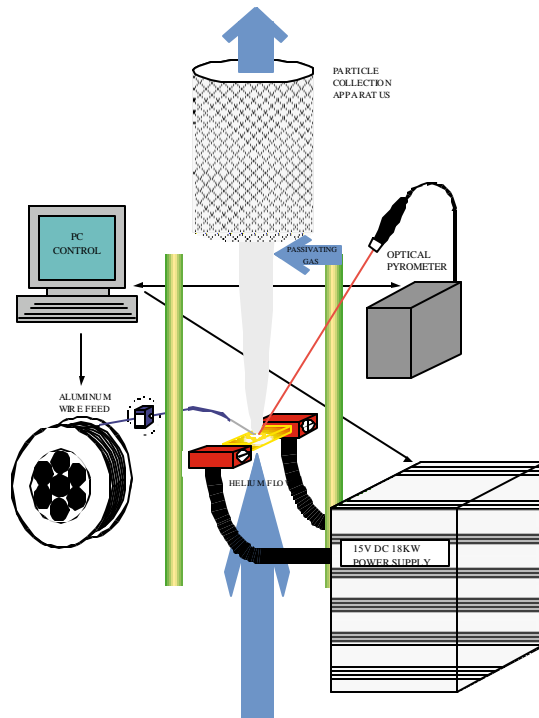
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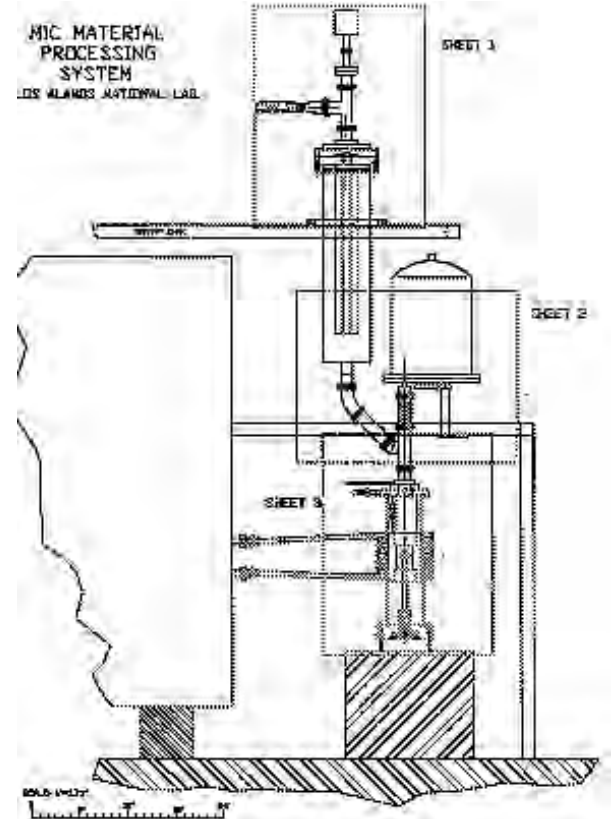


# UFAL/UFM Reactors

## LANL Tech Transfer



**IHDIV Resistance  
Heating Reactor**



**ARDEC RF  
Heating Reactor**

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# MIC Primer Flame Tests



PVU-1/A Primer



1.0 msec Duration

MIC Primer



$t = 1.0$  msec

**>3000 primers have  
been loaded and tested**



$t = 5.0$  msec

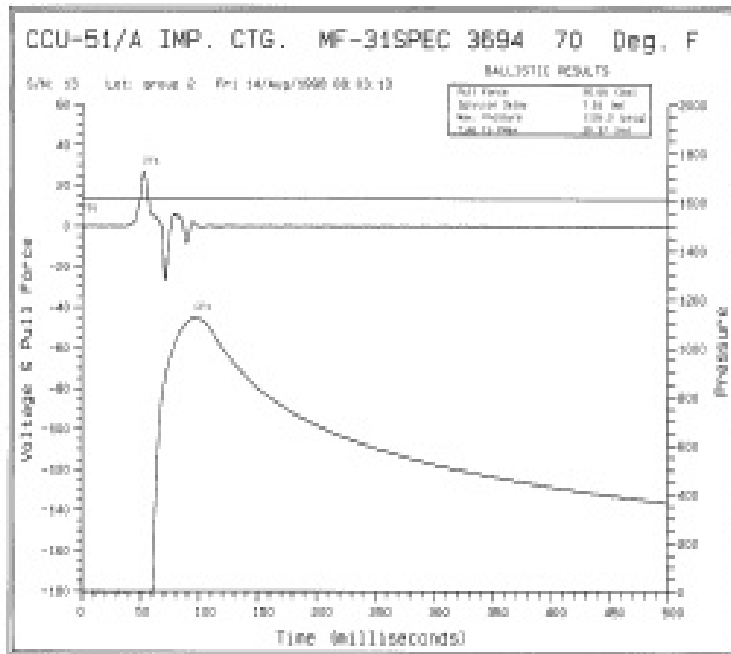
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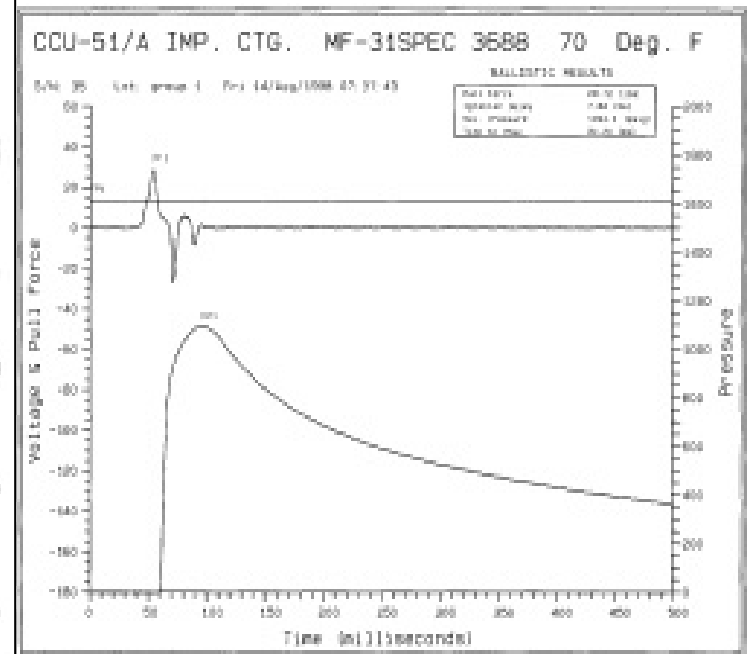
# CCU-51/A Test Results



- MIC Primer



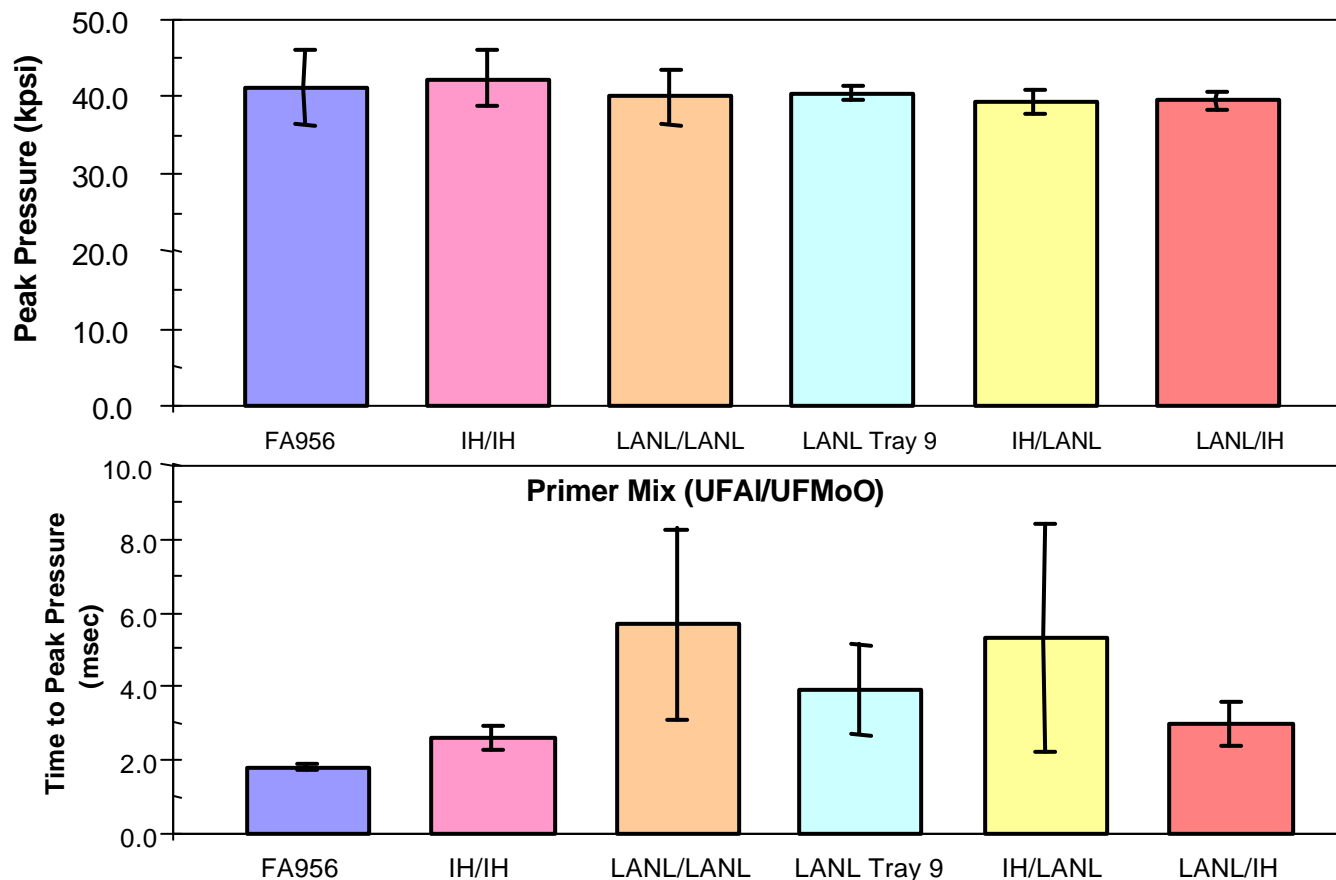
- Standard PVU-1/A Primer



- No Change in Cartridge Internal Ballistics

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# 5.56mm #41 Primer Test Results



- Pressures approaching Lead primer Mean & Standard Deviation
- Time to peak pressure approaching Lead primer values

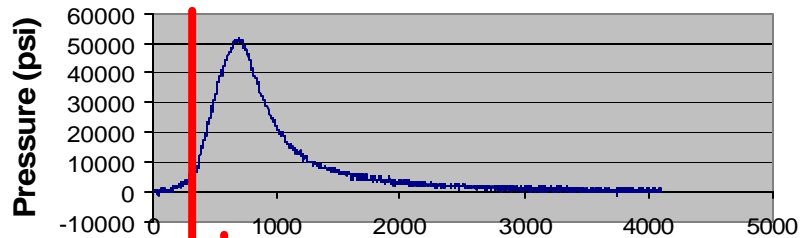
*Committed to Excellence*



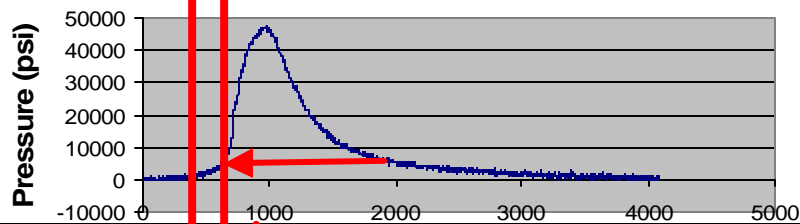
# Green Primer Replacement Effort

## METASTABLE INTERMOLECULAR COMPOSITES

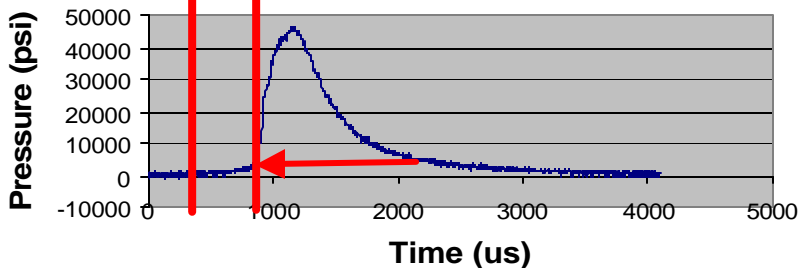
Reference Lot



Config A



Config B



### Ballistic Results:

- Velocity OK
- Pressure OK
- Port Pressure OK
- *Slower Action Time*

### Safety Testing:

- *High Electrostatic Sensitivity*

### Conclusion:

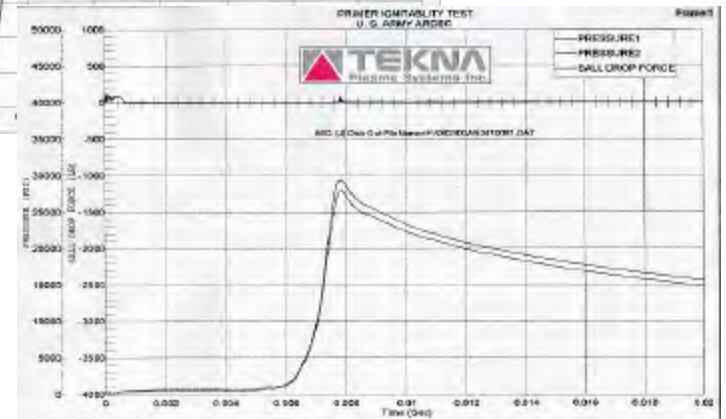
- Requires continued Development

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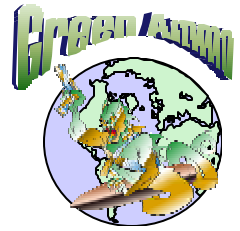


The logo consists of the text "Příroda a život" in a stylized, green, 3D font at the top. Below the text is a circular globe showing the Americas. A large, green, leafy tree is superimposed on the globe, and a small bird is perched on one of its branches.



Committed to Excellence

# Green Primer Replacement Effort COTS Industry Solutions



- **FY01:** JWG Decision to formally evaluate Commercial Alternatives to MIC by Group.
- **CY 01:** Two CBD Announcements for proposed COTS candidates; several responses received.
- **Present:** Three (3) COTS samples purchased and received at CRANE; being shipped to ATK, LCAAP for loading.
- **Near Future:** ‘Fast Track’ test to determine if the previously identified COTS performance deficiencies have been resolved, with Go/NoGo for a follow-on qualification program.



# Green Primer Replacement Effort



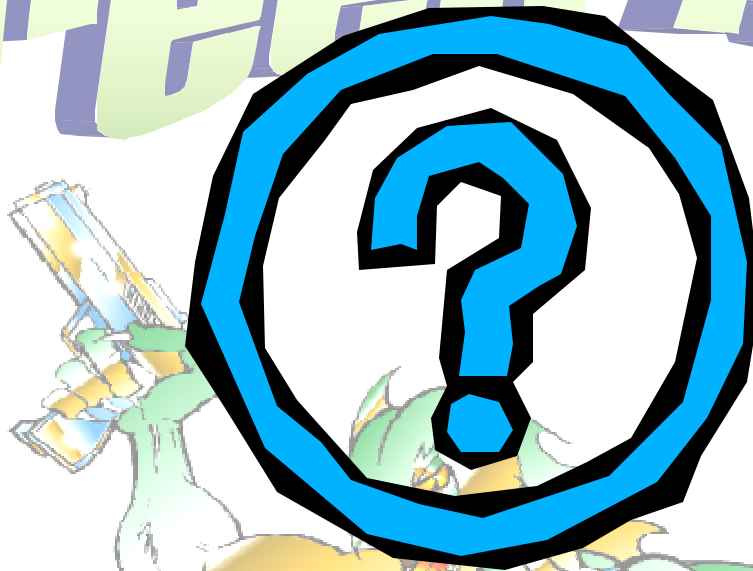
## The Challenges:

Requirement	MIC	COTS
Action Time	<i>x</i>	<i>TBD</i>
Cold Temperature	✓	<i>TBD</i>
Hydroscopicity	✓	<i>TBD</i>
Process Safety	<i>TBD</i>	✓
Process Scaling	<i>TBD</i>	✓





# GREEN AMMO

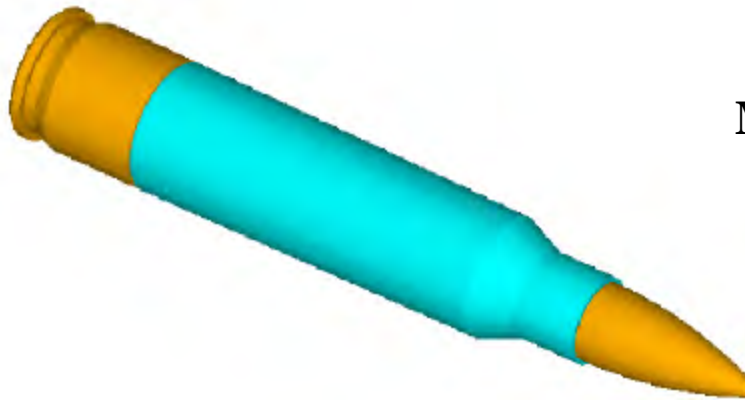


## QUESTIONS

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# **Design, Analysis and Testing of a 5.56mm Polymer Cartridge Case**

**Mr. Alan Hathaway  
Mr. Jeff Siewert  
Arrow Tech Assoc, Inc.  
So. Burlington, VT**



**Dr. Nabil Hussein  
Ms. Laura Henderson  
Amtech, Inc.  
Washington, D.C.**

**2002 International Infantry & Joint Services Small Arms Systems Section  
Symposium, Exhibition & Firing Demonstration  
Atlantic City, NJ**

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## Outline

---

- Introduction
- Goals/Objectives
  - Product
    - Benefits
    - Design
    - Material
  - IB/Modeling Analysis
- Polymer Cartridge Case Analysis & Results
  - Analytical Approach
  - Modeling
  - Results/Conclusions
- Project Status
  - Additional Studies
  - Testing/Interest





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## Goals/Objectives

---

- Polymer-Cased Cartridge
  - Function in Existing Weaponry without Modification
  - Meet Objectives of Standard Brass Specification
  - Provide Cost Effective Transition to Production
  - Serve as “Bridge to the Future” for Lightweight Soldier Initiatives
    - Immediate Savings while Longer-Term Development Items Mature



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## Polymer Case Benefits

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- Directs More Energy to Projectile, Reducing Propellant Requirement to Obtain Comparable Ballistics
- Reduces Heat Transference to Chamber (Natural Insulator)
- Reduces Muzzle Flash
- Provides “Dimensional Memory” for Consistent Weapons Feeding
  - Distortion During Transportation/Handling has No Impact on Chambering/Firing
- Reduces Case Rupture Effect
  - Case Easily Removed Without Damaging Weapon
- Reduces Weight Load on Soldier/Aircraft
- Reduces Manufacturing Cost with Simplified Manufacturing Process
  - Requires No Sealant at Projectile/Case Interface; Self-Sealing Production Process

---

## Polymer Case Design

---

- Design Goals
  - Lightweight Materials that Meet Performance Requirements
    - Minimal “Non-Qualified” Component Materials
  - Manufacturing Process that is Efficient and “Eco-Friendly”
- Current Design Components (5.56mm Cartridge)
  - Zytel Nylon 612 Polymer (Modified - 4<sup>th</sup> Generation) Cartridge Case
  - M855 62 gr. Full Metal Jacket Boat Tail (FMJBT) Projectile
  - Alloy 260 Cartridge Brass Base Cap
  - No. 41 Military Primer
  - Primer Sealant, High Viscosity Purple
  - WCC 844T Propellant



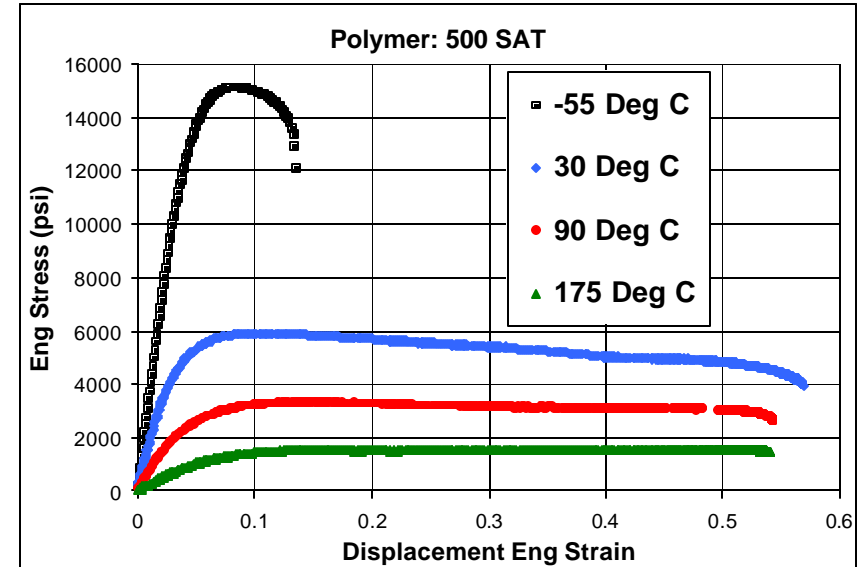
## Polymer Material

- Material Characterization/Accelerated Aging\* Studies
  - Plans Developed by NSWC-Dahlgren, Texas A&M, and Amtech, Inc.
  - Testing Conducted by Texas A&M
  - Analysis and Report Written by Texas A&M – Reviewed by DuPont
  - Results Provided to Arrow Tech Assoc.

### Stress-Strain Curve

#### Studies:

- Include DAM (Dry As Molded) and Saturated Test Samples
- Vary Across Contracted Temperature Ranges (Both Storage and Operational)



\* Accelerated Aging Study in Progress.

---

## Goals/Objectives

---

- IB/Modeling Analysis
  - Validate Actual Testing Results
    - Provide Scientific Basis for Demonstrated Performance
  - Facilitate Expansion into Larger Caliber Cartridges
    - Project Feasible Caliber Range
    - Accelerate Incorporation of Design/Component Improvements



---

## Analytical Approach

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# Perform Modeling and Analysis to Ensure Structural Integrity

- **Analytical Issues:**
  - Brass & Polymer Material Description
  - Chamber Pressure vs. Ammo Conditioning Temp.
  - Case Mouth vs. Chamber Pressure
  - Bolt Mass & Stiffness
- **Case & Chamber Interaction**



---

## Analysis Goals

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- Interior Ballistics Modeling (from test data)
- Case/Chamber Modeling and Analysis
  - Brass (nominal dimensions at hot, ambient, & cold)
  - Polymer (nominal dimensions at hot, ambient, & cold)
  - Dimensional Parametric Studies
  - Investigate Several Gun Chambers: M4, M16A2 & M249

---

## Analysis Approach

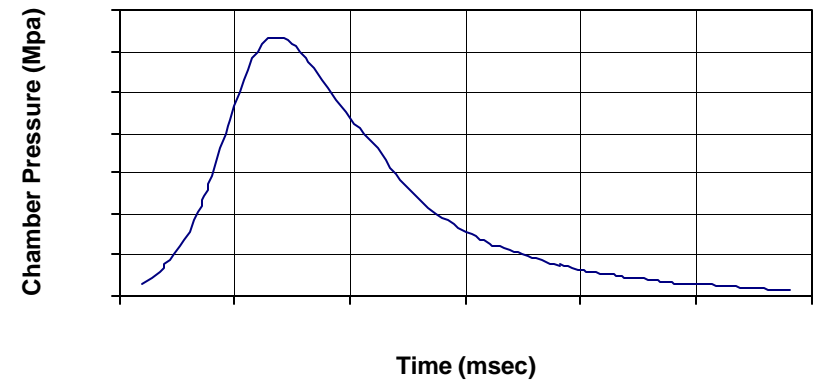
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- **CASAS: CASE Analysis System**
  - Elastic-Plastic, Thermal, Dynamic Solution
  - Models the 5 Phases of Case/Chamber Interaction
    - Initial Conditions (temperature, tolerances, etc.)
    - Propellant Ignition
    - Pressure Load Increase
    - Elastic Recovery
    - Residual Interference (or clearance)
  - Evaluate Peak Material Strain and Peak Bolt Loads
  - Lumped Parameter FEM Model
  - Alternative to General Purpose FEM Programs
  - Ideal for Performing Trade-off Studies During Design

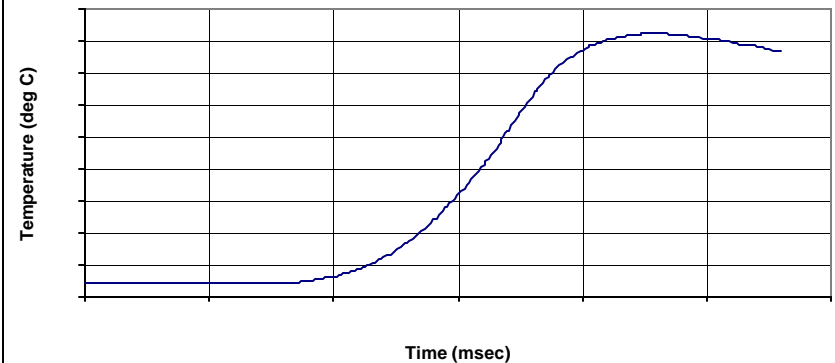
## Data Requirements

- Forcing Functions
  - Pressure (P-T Curve)
  - Temperature
- Material Properties
  - Cartridge Case
    - Density, Modulus
    - Diffusivity
    - Coeff. of Thermal Expansion
    - Stress-Strain Curves
  - Chamber
    - Modulus
    - Diffusivity
  - Case/Chamber Interface
    - Static Coeff. of Friction
    - Dynamic Coeff. of Friction

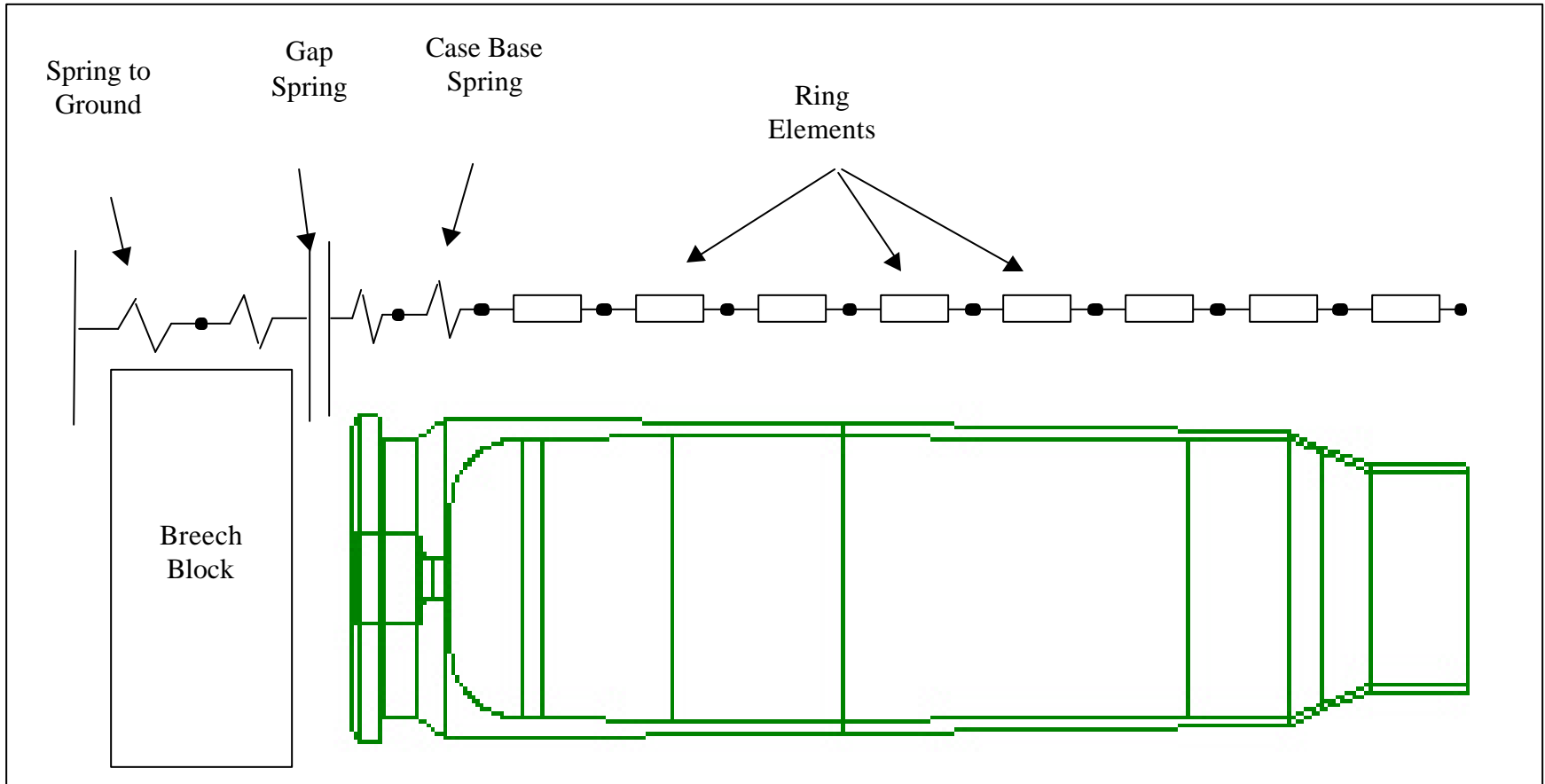
Chamber Pressure vs Time



Case Inside Surface Temperature Profile (IBHVG2)

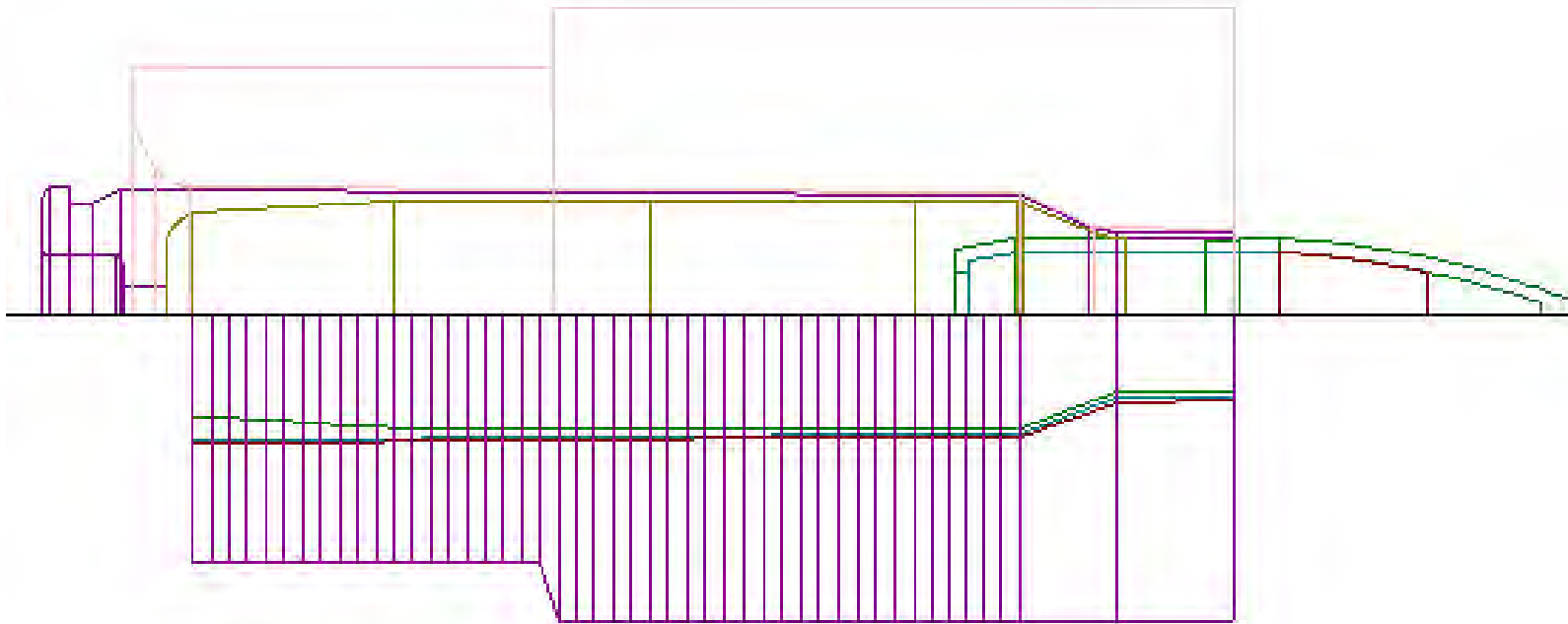


## Lumped Parameter Model

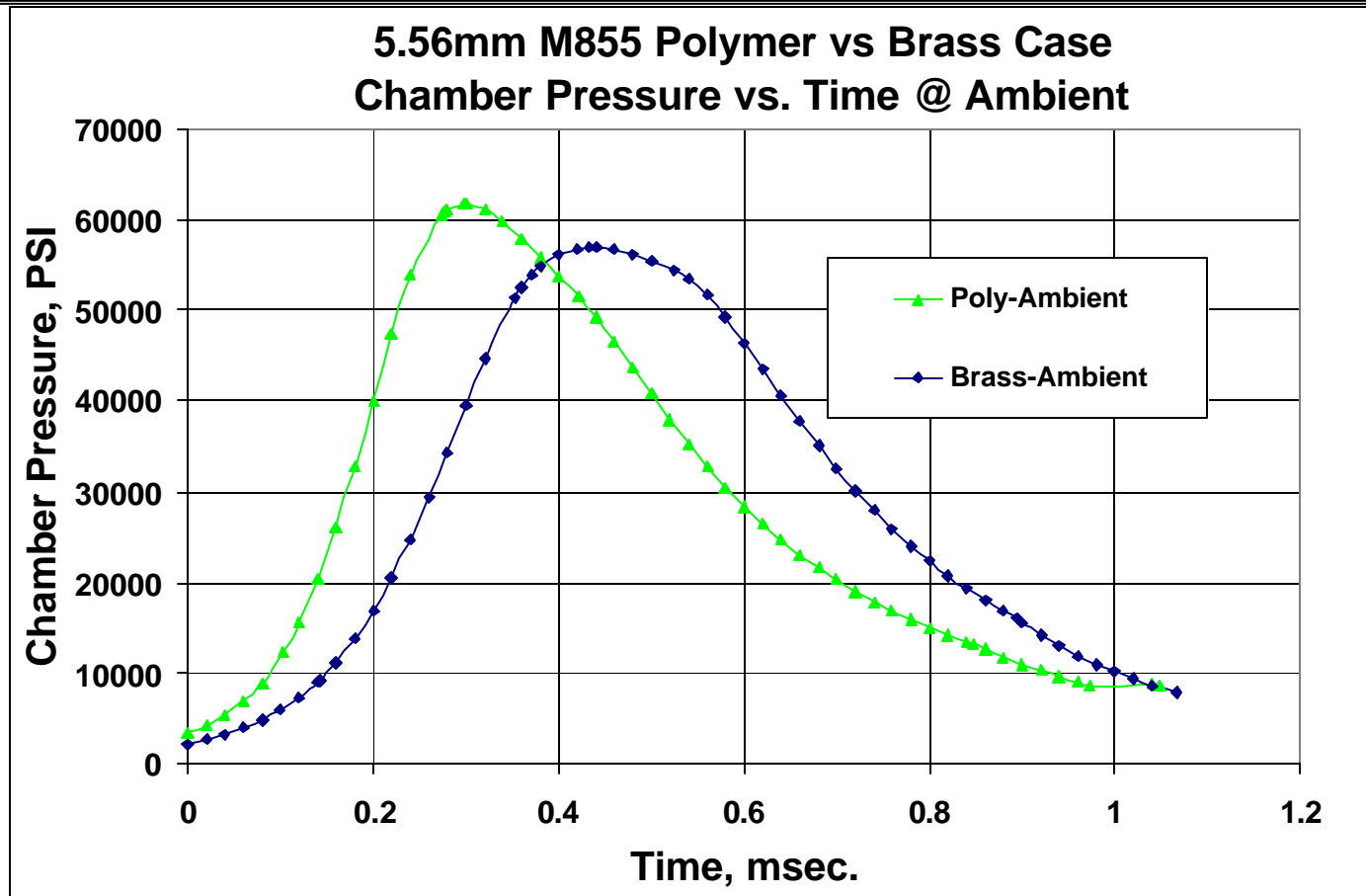


## Lumped Parameter Model

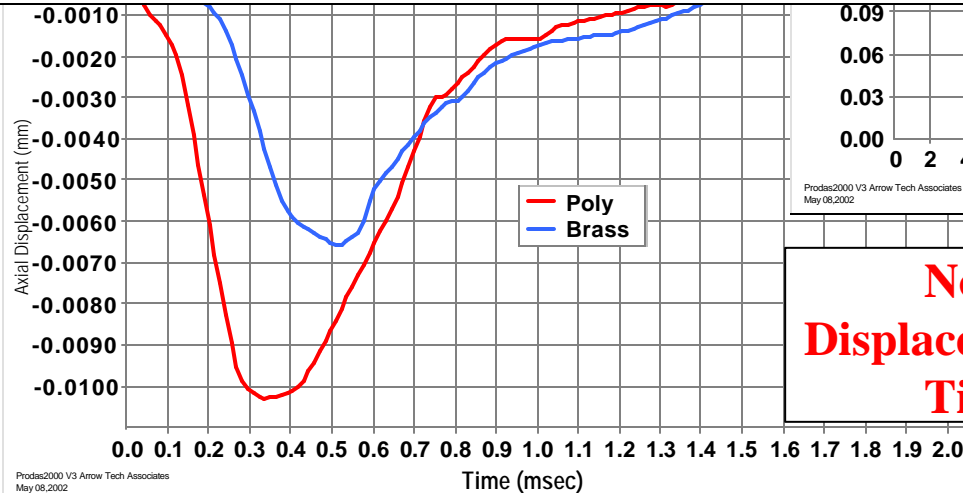
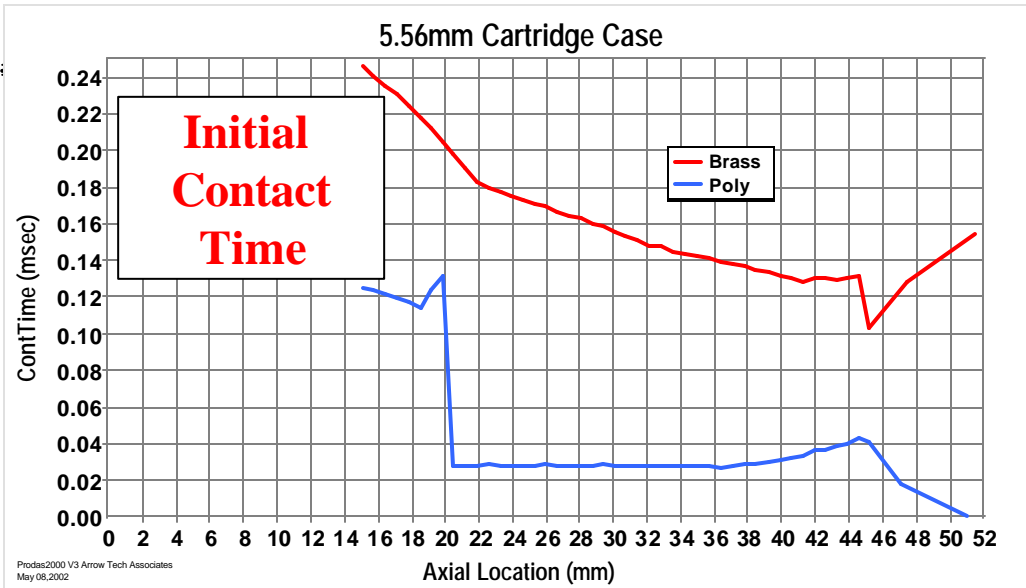
Lumped Parameter Model of the Gun Chamber  
and the Cartridge Case is Generated  
Automatically within PRODAS



## Analysis Results - Ballistics

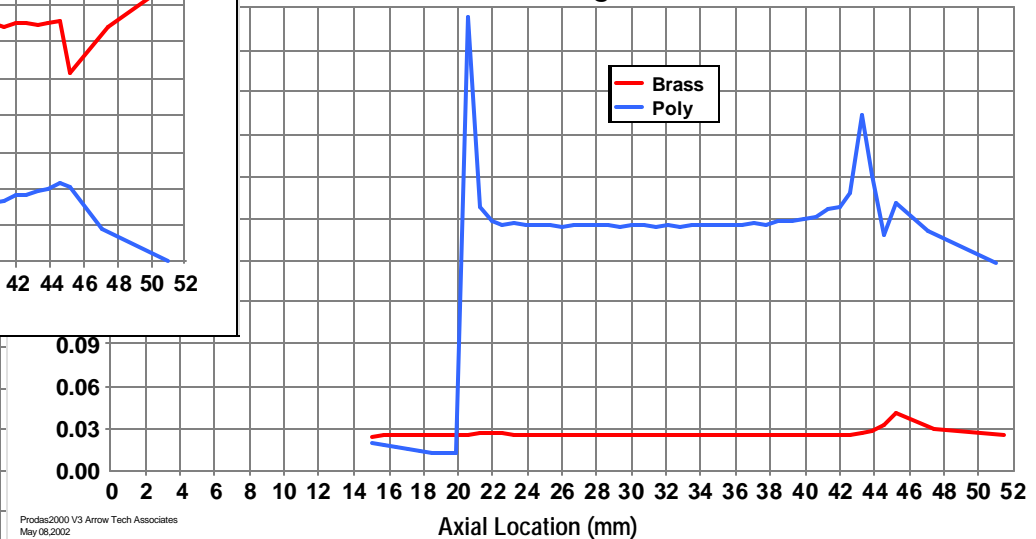






**Total Strain vs. Location**

**5.56mm Cartridge Case**

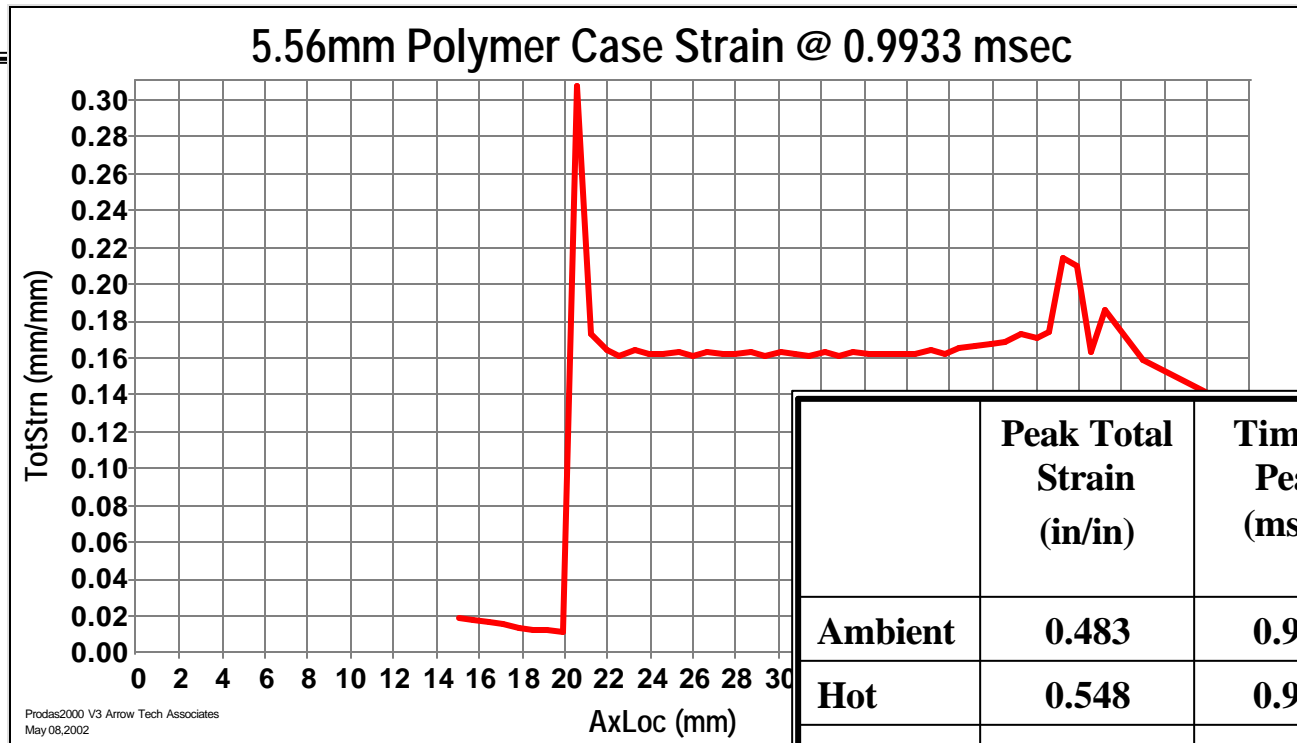


## Analysis Results – Total Strain

<i>Case/Condition</i>	<i>Peak Total Plastic Strain (in/in)</i>	<i>Time at Peak (msec)</i>	<i>Elastic Strain (in/in)</i>	<i>Total Strain (in/in)</i>	<i>Percent of Ultimate Strain</i>
Brass-Cold	0.044	1.235	0.004	0.048	40%
Brass-Ambient	0.044	1.060	0.004	0.048	40%
Brass-Hot	0.049	1.034	0.004	0.053	44%
Polymer-Cold	0.275	1.544	0.02	0.295	52%
Polymer-Ambient	0.284	1.503	0.02	0.304	53%
Polymer-Hot	0.313	1.503	0.02	0.333	58%

## Analysis Results – Dimensional Strain

<i>Case Scenario</i>	<i>Temp. Condition</i>	<i>Axial Plastic Strain (in/in)</i>	<i>Total Strain (in/in)</i>	<i>Percent of Ultimate Strain</i>
Min Case/Min Cham	Ambient	0.146	0.341	60%
Min Case/Max Cham	Ambient	0.258	0.477	84%
Max Case/Min Cham	Ambient	0.099	0.274	48%
Max Case/Max Cham	Ambient	0.099	0.275	48%
Min Case/Max Cham	Hot	0.273	0.529	93%
Nominal	Ambient	0.118	0.304	53%



	Peak Total Strain (in/in)	Time of Peak (msec)	Axial Location (from base of PRODAS model) of Peak (in)
Ambient	0.483	0.993	0.782
Hot	0.548	0.993	0.782
Cold	0.511	0.993	0.782

*At Ambient:*

Total Elastic Strain (0.033) + Plastic Strain (0.483) = Total Strain (0.516)

***Worst Case: Total Strain of 0.516 is approx. 90% of ultimate strain (0.57)***

---

## Analysis Results - Summary

---

- IB/Modeling Analysis of Amtech 5.56mm Polymer Case
  - Design Indicated as Structurally Adequate, with Peak Total Strain Yielding Sufficient Margin to Ensure Function Without Separation at All Temperature Conditions
    - At Nominal Dimension, the Amtech Polymer Case Performs at 52-58% of Ultimate Strain; Worst Case ~ 90% of Ultimate Strain
  - Less Interior Ballistic Variation over Temperature Range than Brass Case
  - Lower Total Impulse Delivered than Brass Case
  - Lower Heat Transfer to Chamber than Brass Case
  - Lower Initial Extraction Force than Brass Case
- Model Validates Demonstrated Testing Performance

---

## Project Status - Analysis Studies

---

- Additional Studies
  - 7.62mm Initial Study Complete
    - Scaled Up Simulation Model Predicts Actual Testing Results
    - Design Indicated as Structurally Adequate, with Peak Total Strain Yielding Sufficient Margin to Ensure Function Without Separation at All Temperature Conditions
  - 50 cal. and Larger Calibers to be Studied as Project Progresses





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## Project Status – U.S. Military Testing

---

- Amtech 5.56mm Polymer-Cased Ammunition
  - Passed Final Pre-Qualification Screening Test Conducted for Office of Naval Research (ONR) Contract
  - Passed Safety Certification Testing Conducted by Aberdeen for USSOCOM
    - Cartridges Procured to Begin Initial User Evaluation
  - Scheduling Pre-Qualification Test for ARDEC at Picatinny Arsenal (Standard LAT + Additional Tests)
    - Successful Test Results to be Followed by Army Pre-Production Qualification Testing



# ***REDUCING TARGET DISPERSION FOR HIGH MASS AND LOW VELOCITY PROJECTILES***

**Ted Haeselich**

**NICO Pyrotechnik  
22946 Trittau,  
GERMANY**

**Roy Kelly**

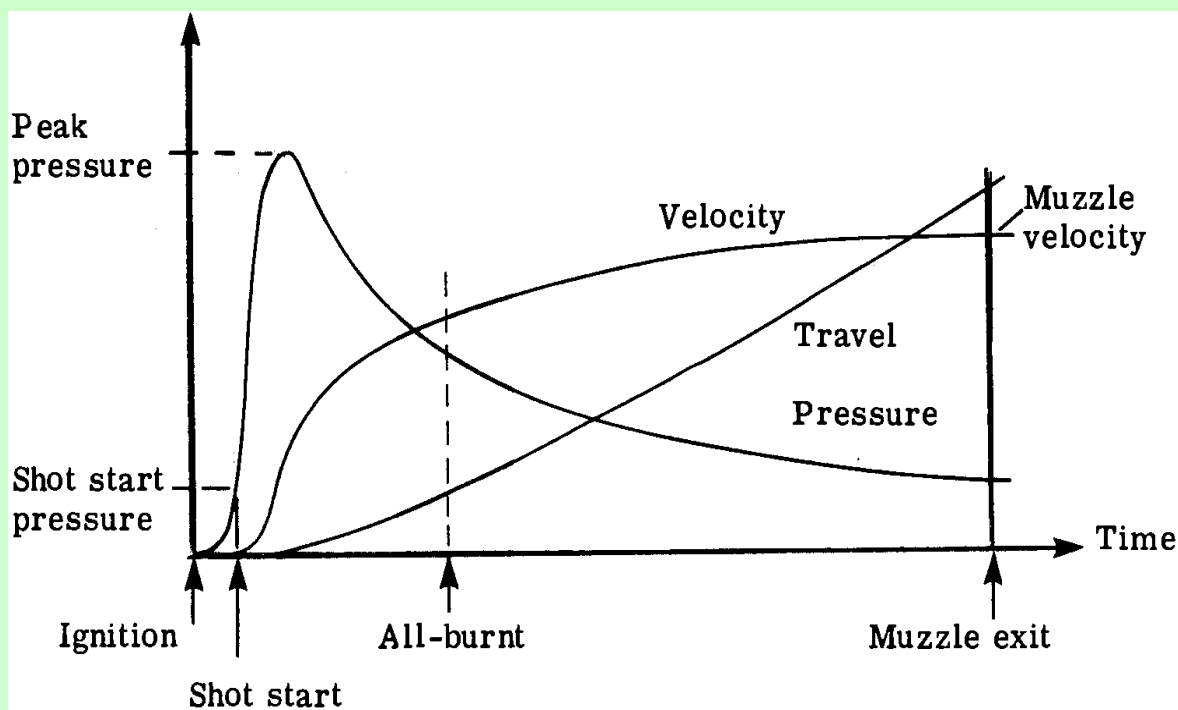
**Delta Defense, Inc.  
1111 Jefferson Davis Hwy  
Suite 508  
Arlington, Virginia 22202**

***NDIA 2002 International Infantry & Small Arms Symposium  
Session X - Small Arms Technology & Systems***

## ***IDEAL INTERNAL BALLISTICS FOR GUN FIRED ORDNANCE***

- **Modern single and double based propellants work best at high pressures to ensure complete combustion of the powder soon after the projectile moves (shot start)**
- **This ensures reproducible muzzle velocities independent of crimping force and only slightly dependent on ambient temperature**

## **IDEAL PRESSURE/TIME, TRAVEL/TIME & VELOCITY/TIME CURVES**



**The ideal system works best at high velocities and high pressures**

## ***NON-IDEAL INTERNAL BALLISTICS***

- For low velocities and low pressures there is little resistance to projectile travel. The propellant burns into an increasing volume which restricts the rise in pressure and limits the increase in burning rate.
- As a consequence, not all propellant is burnt at shot exit leading to erratic muzzle velocities and high target dispersion
- In this situation, muzzle velocities and target dispersion become very dependent on ambient temperature

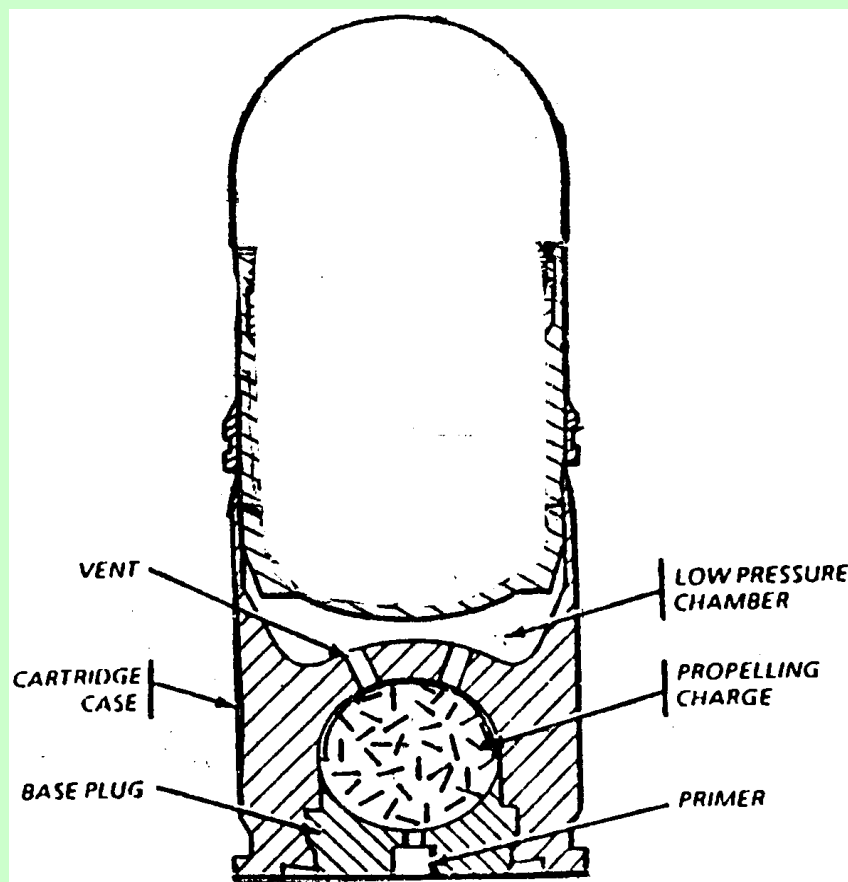
## ***PRINCIPLE OF HIGH-LOW PRESSURE PROPULSION SYSTEMS***

- **Separate high and low pressure chambers are adopted in some systems such as 40mm cartridges**
- **This ensures that the propellant burns at high pressure until a copper disc is ruptured between the high and low pressure chambers**
- **Even so, all the powder may not be burnt before shot exit, particularly at low ambient temperatures**



## STANDARD US CARTRIDGE CASE DESIGN FOR 40MM HIGH VELOCITY PROJECTILES

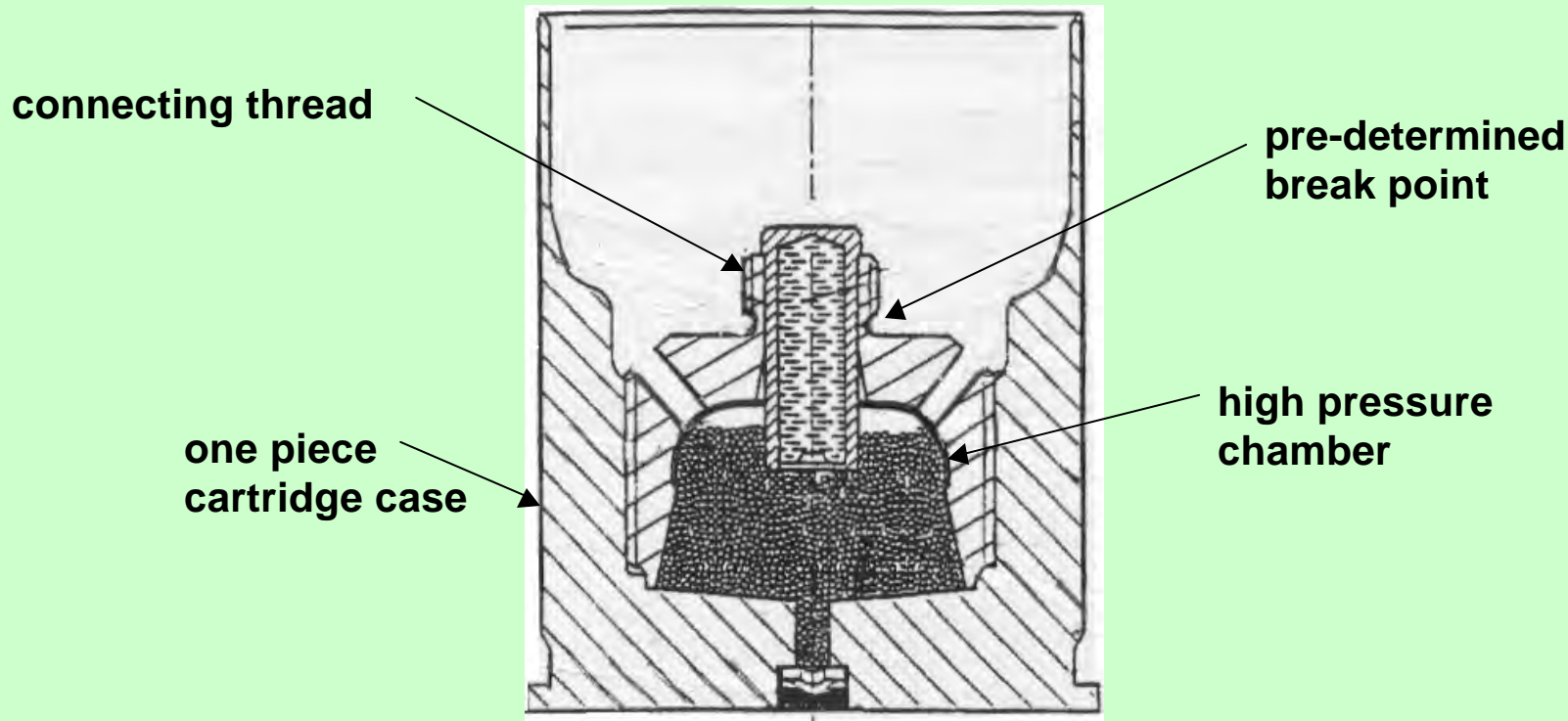
- **M430 (HEDP)**
- **M385 (Inert Slug)**
- **M918 (Flash/Bang)**



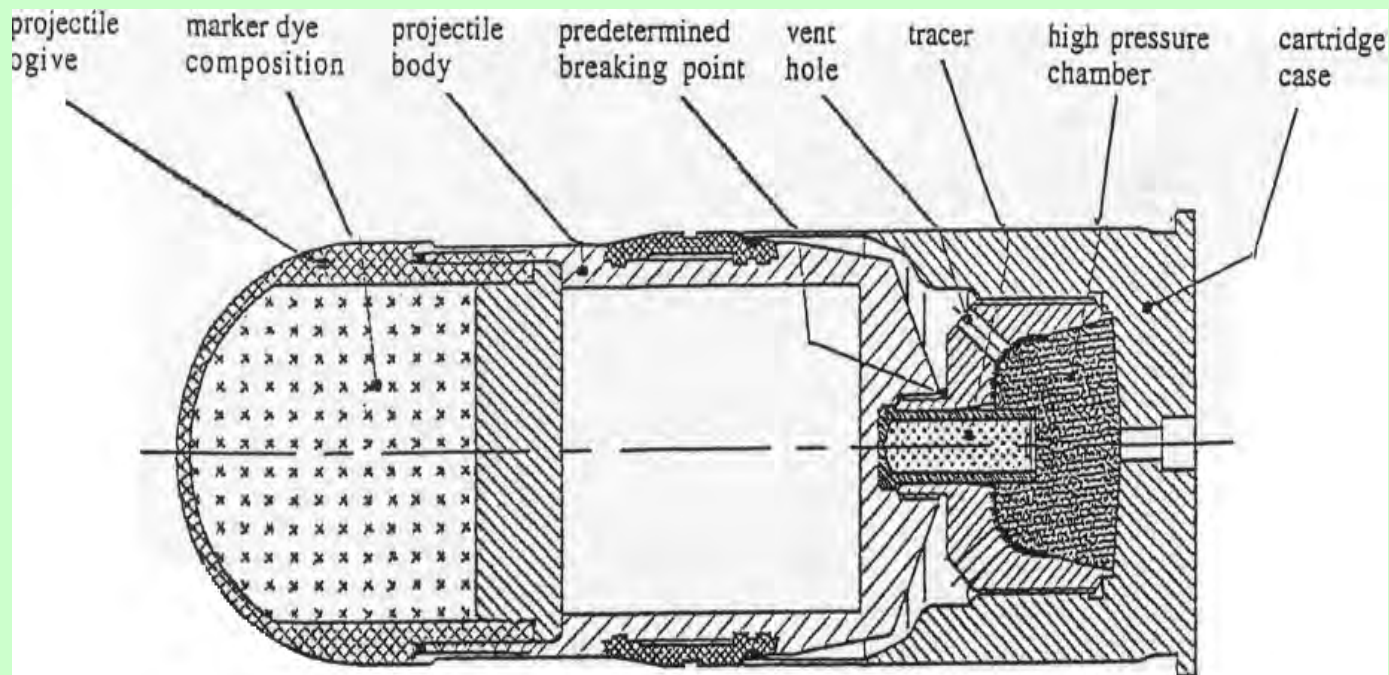
## ***PRINCIPLE OF NICO HIGH-LOW PRESSURE PROPULSION SYSTEM***

- The cartridge case is screwed to the projectile during assembly
- Shot start occurs when sufficient pressure is reached in the low pressure chamber to rupture the connection between the cartridge case and the projectile
- This occurs at a pre-determined break point at the base of the screw connection between the projectile and its case

# ***NICO PROPUSION SYSTEM DESIGN FOR 40MM HIGH VELOCITY PROJECTILES***



## ***TYPICAL NICO CARTRIDGE FOR 40MM HIGH VELOCITY PROJECTILES***



**40mm x 53 Practice Cartridge with Impact Signature and Tracer**

## ***ADVANTAGES OF NICO CARTRIDGE CASE DESIGN***

- **Dispersion is reduced because the propellant burns faster at the higher pressure and is all consumed before shot exit**
- **The one piece cartridge case removes the need for a separate base plug**
- **The design permits the use of a tracer**

## ***40mm MOPI REQUIREMENT TESTING AT MEPPEN***

				<b>SD of Dispersion at 300m</b>	<b>SD of Dispersion at 300m</b>
<b>Cartridge type</b>	<b>Temp (C)</b>	<b>Vo (mps)</b>	<b>SD (mps)</b>	<b>Width (m)</b>	<b>Height (m)</b>
<b>NICO 40mm</b>	<b>+21</b>	<b>240.4</b>	<b>2.3</b>	<b>0.52</b>	<b>0.31</b>
<b>NICO 40mm</b>	<b>+52</b>	<b>241.8</b>	<b>2.4</b>	<b>0.63</b>	<b>0.37</b>
<b>NICO 40mm</b>	<b>-35</b>	<b>238.5</b>	<b>2.5</b>	<b>0.74</b>	<b>0.45</b>
<b>M430</b>	<b>+21</b>	<b>242.5</b>	<b>2.9</b>	<b>0.82</b>	<b>0.61</b>
<b>M430</b>	<b>+52</b>	<b>246.8</b>	<b>3.4</b>	<b>1.05</b>	<b>0.83</b>
<b>M430</b>	<b>-35</b>	<b>227.6</b>	<b>4.8</b>	<b>1.64</b>	<b>1.04</b>



## ***SUMMARY***

- **The NICO propulsion system design reduces projectile dispersion on the target**
- **A family of 40mm cartridges (Practice, CS, OC, Flash/Bang) has been designed around the NICO propulsion system**
- **NICO's propulsion system has been adopted in 40mm air-bursting programmable ammunition for USSOCOM's Advanced Lightweight Grenade Launcher (ALGL) program**



# FRANGIBLE AMMUNITION

May 15, 2002

**Sung Kim**  
**Ammunition Branch, Code 4083**  
**Weapons Department**  
**Ordnance Engineering Directorate**  
**Naval Surface Warfare Center, Crane Division**  
**Crane, Indiana**

**Comm.: (812) 854-5807    DSN: 482-5807    FAX: 1044    E-mail: [kim\\_s@crane.navy.mil](mailto:kim_s@crane.navy.mil)**



# FRANGIBLE AMMUNITION

---

- OBJECTIVES
- WHO USES FRANGIBLE?
- REQUIREMENTS
- NSWC, CRANE FRANGIBLE PROGRAMS
- PROBLEMS AND CONCERNS



# TRAINING OBJECTIVES

---

Frangible ammunition should:

- Cause Minimal damage to training facility
- Eliminate lead/toxic emission around shooter
- Eliminate lead/toxic accumulation down range
- Reduce ricochet hazard



# OPERATIONAL OBJECTIVES

---

Frangible ammunition should:

- Be lethal
- Be accurate (100Meters)
- Reduce ricochet hazards
- Reduce hard target penetration
- Be used for
  - Close Quarter Battle (CQB)
  - Military operation in Urban Terrain (MOUT)
  - Visit Board Search and Seizure
  - Counter-Narcotics (CN) Operation



# WHO USES IT?

---

Approved users are:

- Naval Special Warfare Command (SPECWARCOM)
- Chief of Naval Education and Training (CNET)
  - RTC Great Lakes
- U. S. Air Force
- U.S. Marine Corps





# WEAPONS

---

## ➤ 5.56mm

- M16A2 Rifle
- M4A1 Carbine
- M247 SAW
- Mk 46 Light Machine Gun

## ➤ 9mm

- M9 Pistol
- M11 Pistol
- P226 Pistol
- MP5 Sub-Machine Guns

## ➤ 45 Cal

- M1911A Pistol
- Mk23 Offensive Handgun



# U.S. MARINE Operational Requirements Document

---

➤ U.S. Marine issued ODR for Close Quarter Battle Weapon, NO. INS. 1.14 (August 94)

➤ The intent of the CQBW was to replace the MP5s Sub-machine Guns used by MEUSOC and MCSF with M4 Carbine

➤ The ORD identified two rounds, two missions

➤ Training

➤ Operational

➤ Revision 20 March 1998

➤ The Revision identified one round, two missions



# SPECWARCOM

## Join Operational Requirements Document

---

- SPECWARCOM Finalized Joint Operational Requirements Document (JORD) (April 98)
  - Based on frangible technology and operational requirements
  - JORD was reviewed by other USSOCOM activities
- USSOCOM Approved JORD (Aug 98)
  - 3 Calibers; 5.56MM, 9MM, and .45 Caliber
- One round two missions
  - Training
  - Operational



# REQUAIED CAPABILITY

---

- Must be lead-free/non-toxic
- Must function weapon as reliably as current NATO Ball cartridges
- Must not penetrate background materials (**Shoot Houses**)
  - 3/8 in. AR500
- Must be waterproofed
- Must be no reverse splatter
- Must be no hazardous ricochet



# REQUAIED CAPABILITY

---

- Must have primer sensitivity comparable to lead based primers
- 5.56mm and 9mm/.45 cal. must meet following requirements at 100M and 50M respectively:
  - Accuracy comparable to current NATO Ball cartridge
  - Adequate lethality
  - Ballistic match for current NATO cartridge



## U.S. MARINE 5.56mm Safety Certification

---

- NSWCC, Crane conducted Performance Evaluation to determine if any commercially available cartridges could meet the ORD requirements (June 98)
  - None of the cartridge designs met all Operational Requirements
  - Winchester Ranger was Selected by USMC





# U.S. MARINE 5.56mm Safety Certification

---

- March 1999
  - USMC Task Crane to
    - Catalog
    - Conduct Safety Certification Testing
    - Obtain WSESRB Release
- Testing Completed January 2000
- May 2000 WSESRB issued Safety Approval for release (AA40)



# SPECWARCOM

## Solicitation of Cartridges

---

- WARCOM task Crane to procure and Safety Certify 5.56MM, 9MM and .45 Caliber Frangible Ammunition (Nov 98)
- Specifications prepared based of JORD requirements
- Solicitation issued February 1999 (5.56MM)
- Five Vendors responded and provided bid samples



# SPECWARCOM

## 5.56mm Safety Certification

---

- Evaluation of Bid Samples completed (July 99)
  - None of the samples met all the performance requirements
  - Acceptable function & casualty, lethality, accuracy, ballistic match
  - Deficiencies:
    - Over penetration on hard target
    - Primer sensitivity
    - Waterproof
- Specification modified



# SPECWARCOM

## 5.56mm Safety Certification

---

- Reissued solicitation (Dec 99)
  - Dropped lead-free primer requirement
  - Emphasized accuracy, lethality and no backstop penetration (AR500 Steel Plate)
  - Two previous vendors responded w/bid samples



# SPECWARCOM

## 5.56mm Safety Certification

---

- Conducted 2<sup>nd</sup> bid sample evaluations (Mar 00)
  - Neither vendor's samples met all performance requirements
  - Deficiencies:
    - Over penetration on hard target
    - Accuracy
    - Waterproof
    - Function and Casualty
- Based on test results WARCOM suspended action Pending development of R<sup>2</sup>LP cartridge (April 00)



# SPECWARCOM

9mm and .45 Cal.  
Solicitation

---

➤ Solicitation for 9mm and Caliber .45 issued  
(May 99)

➤ Five Vendors responded for 9MM

➤ Four Vendors responded for .45 Caliber





# SPECWARCOM

9mm and .45 Cal.  
Safety Certification

---

- Evaluation of Bid Samples completed (Jan 00)
  - None of vendors met all of the requirements
  - Deficiencies:
    - Function & Reliability
    - Over penetration on Drywall
    - Primer sensitivity
    - Waterproofing
- SPECWARCOM dropped requirement



# CNET

## 9mm Safety Certification

---

- NSWCC Crane tasked by Chief Naval Education & Training (CNET) to obtain WSESRB release for 9MM Frangible Ammunition (Mar 00)
  - Handgun Marksmanship Training @ RTC Great Lakes
- Cartridge Salient Characteristics
  - Lead Free/Non-Toxic
  - Function Beretta M9 Pistol
  - Reduced ricochet/Penetration
- It was determined that the CNET requirements were within the WARCOM JORD



# CNET

## 9mm Safety Certification

---

- Minimal additional testing was required
  - Function and Casualty
  - AR500 Steel Plate Penetration
  - Ricochet
- SNC cartridge configuration best conformed to specification requirements
- Received JAG approval for training use by CNET (June 00)
- WSESRB issued safety approval (July 00)
  - AA16



# USAF 9mm Safety Certification

---

- NSWCC Crane tasked by USAF Security Force to Procure AA16, 9mm Frangible Ammunition (Jan 02)
  - Weapon qualification and proficiency Training
- Cartridge Salient Characteristics
  - Lead Free/Non-Toxic
  - Function Beretta M9 Pistol
  - Reduced ricochet/Penetration
- AA16, 9mm Frangible Ammunition is approved by Non-Nuclear Munitions Safety Board



# SPECWARCOM

## 5.56mm Frangible Requirement

---

- WARCOM identified a requirement for 5.56MM Frangible ammunition for training (Mar 2001)
  - For CONUS and OCONUS use
  - This requirement to fill training requirements until the R<sup>2</sup>LP Cartridge is fully developed
- JAG approved 5.56mm frangible cartridge for training use only, CONUS/OCONUS (May 01)
- WSESRB issued safety approval for CQB and Indoor Training (Sept 01)
- WSESRB extended approval to use outdoors (Jan 02)



# SPECWARCOM

## 9mm Frangible Requirement

---

- WARCOM identified a requirement for AA16, 9mm Frangible Ammunition for training
  - CONUS
  - OCONUS
  - For use in Sig Sauer P226, P228 and H&K MP5 Sub-Machineguns
- Received JAG approval for training use only by WARCOM units and CNET (Feb 02)
- Received WSESRB safety approval (Feb 02)





# PROBLEMS & CONCERNS

---

- No-lead primer not meeting military operational requirements at extreme temperatures
- Need improved waterproofing
- Over-penetration on hard targets
- Over-penetration on soft targets (9mm)
- High Failure Rate of 9mm in MP5s



R<sup>2</sup>LP

---

➤ Reduced Ricochet, Limited Penetration (R<sup>2</sup>LP)  
Cartridge is being developed to meet current frangible ammunition requirements.



# INDIVIDUAL PROTECTION

## ***Advanced Soldier Ballistic Protection***

## ***2002 International Infantry Conference***

***15 May 2002***

Mr. Robert F. Kinney  
(508) 233-4308; DSN: 256-4308  
Email: [robert.kinney@natick.army.mil](mailto:robert.kinney@natick.army.mil)



## DIRECTORATE



# Current Ballistic Protection

## • *Interceptor & Small Arms Protective Insert*

Vest: 7.8-8.4 lb, Torso coverage

Protects against:

Conventional frag, handgun

SAPI: 4 lb

Conventional ball rounds



## • *Full Spectrum Battle Equipment (FSBE)*

*Reduced* area of coverage

SAPI



## • *BALCS*

Vest: 6.5 lb

Level IV Plate: 6 lb

## • *Standard PASGT*

## • *Modular/Integrated Communications Helmet (MICH)*

## • *Lightweight Helmet*

Helmet : 3 lb

Protects against conventional frag, 9mm

Improved Suspension system



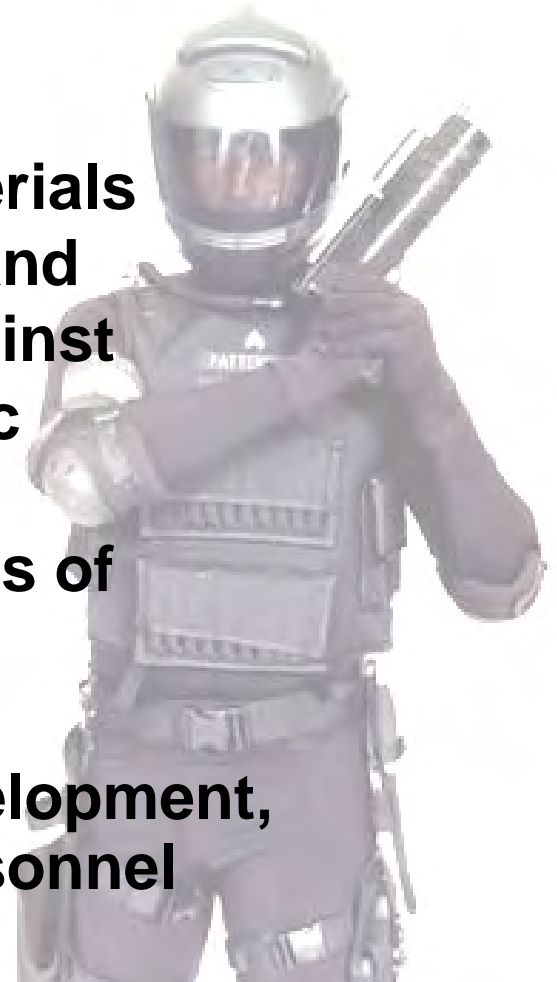


# Advanced Soldier Ballistic Protection

## Objectives

... Develop/insert advances in materials technology to *improve protection* and performance of armor systems against conventional and emerging ballistic threats while *minimizing penalties* associated with the increased levels of protection.

... *Provide tools* to benefit the development, design, test and acquisition of personnel armor.

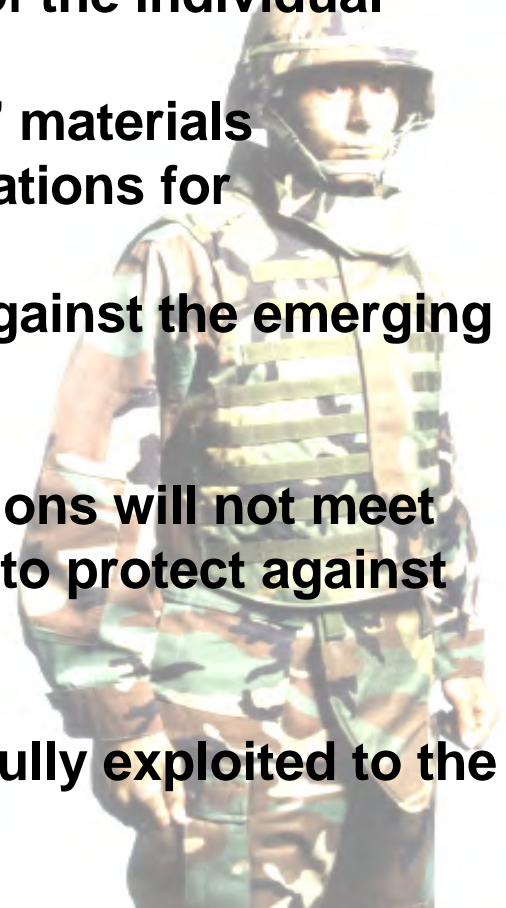




# Advanced Soldier Ballistic Protection

## Why do this work?

- **Armor is a significant contributor to the load of the individual warfighter.**
  - **Today's armor employs "state-of-the-art" materials (ceramics/textiles) in traditional configurations for conventional threat protection.**
  - **Minimal protection is presently offered against the emerging threats.**
- **Current state-of-the-art technology configurations will not meet future personnel armor systems weight goals to protect against conventional or emerging ballistic threats.**
- **Existing materials technology have not been fully exploited to the optimal performance levels.**







# Advanced Soldier Ballistic Protection

## Why do this work?

- Current methodology(s) for assessing the behind armor effects of non-penetrating impacts onto body armor (helmet and vests) tend to assess the mechanical performance of the armor system.
- Standards to assess “blunt trauma” that are presently employed have a limited biomechanical foundation
- Current casualty reduction assessments are performed using models such as CASRED or Full Spray Lethal Area that are limited due to:
  - Lack of flexibility to represent multiple fragment materials (e.g., steel, tungsten)
  - Poor representation of human targets and body armor coverage
  - Limited representation of fragment penetration algorithms
  - No capability to easily change algorithm parameters
  - Lack of adequate representation of casualty effects



# Advanced Soldier Ballistic Protection

## Payoffs

- **Light weight personnel armor with significant increase in ballistic protection - Depending on threat - up to a 40% reduction in ballistic materials weight over start point of this DTO**
- **Better protection and lighter weight equates to improved survivability and tactical mobility for the individual**
- **Enhanced analytical tools for body armor development, test and evaluation and acquisition/ fielding**
- **More realistic survivability assessment**

# Advanced Soldier Ballistic Protection

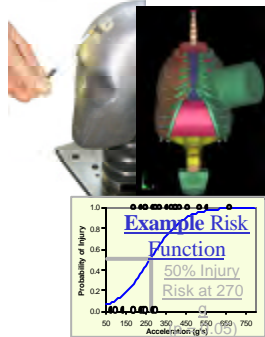
**Conventional Threats**  
Steel Fragments  
Small Arms Bullets –  
Lead and Steel Cored

**Emerging Threats**  
Low Mass, High Density Fragments  
Small Arms Bullets –  
Tungsten Carbide Cored

**Behind Armor Effects  
Methodology**

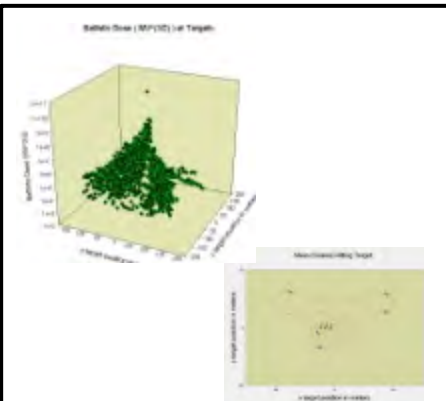
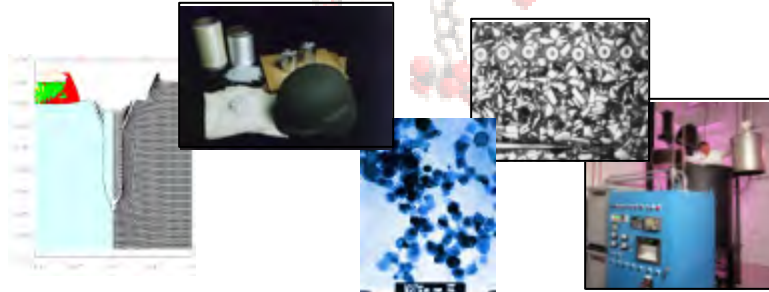
**Advanced Technology  
Development**

**Casualty Reduction  
Analysis Model**



**Conduct experimental (tissue & test fixture), analytical and numerical assessments of non-penetrating impact on body armor/body**

- New high performance polymers/ fibers/composites
- Nanotechnology
- Advanced ceramics & metals
- Enhanced predictive modeling
- Material systems integration



**Develop/update models for armor system performance from threat definition to incapacitation effect**

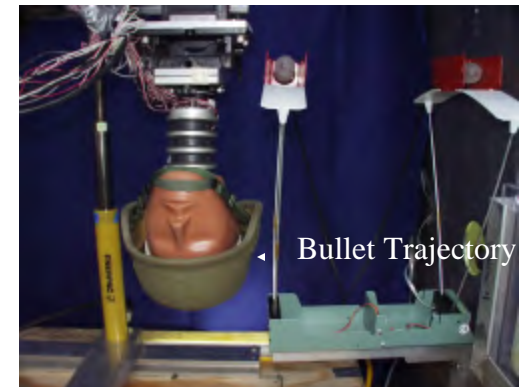


# Advanced Soldier Ballistic Protection

## Behind Armor Effects - Helmet Assessment Methodology

- Objective, dynamic biomechanical test method for accurately determining skull fracture potential of non-penetrating ballistic impacts on helmets.
- Human Impact Location
  - Temporoparietal Bone
  - Near the Lambdoidal Suture
  - Above the Frankfort Plane
- Validated through mechanical and cadaveric experimentation
- Established a risk of injury (fracture) curve for 9mm impacts on the helmet at various velocities

First objective method  
in the world  
based on biomechanics



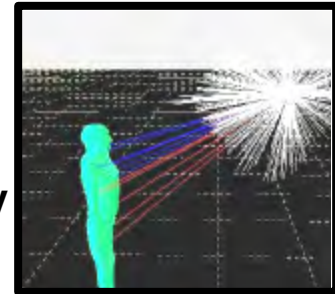


# Advanced Soldier Ballistic Protection

## Integrated Casualty Estimation Methodology

### Key Accomplishments:

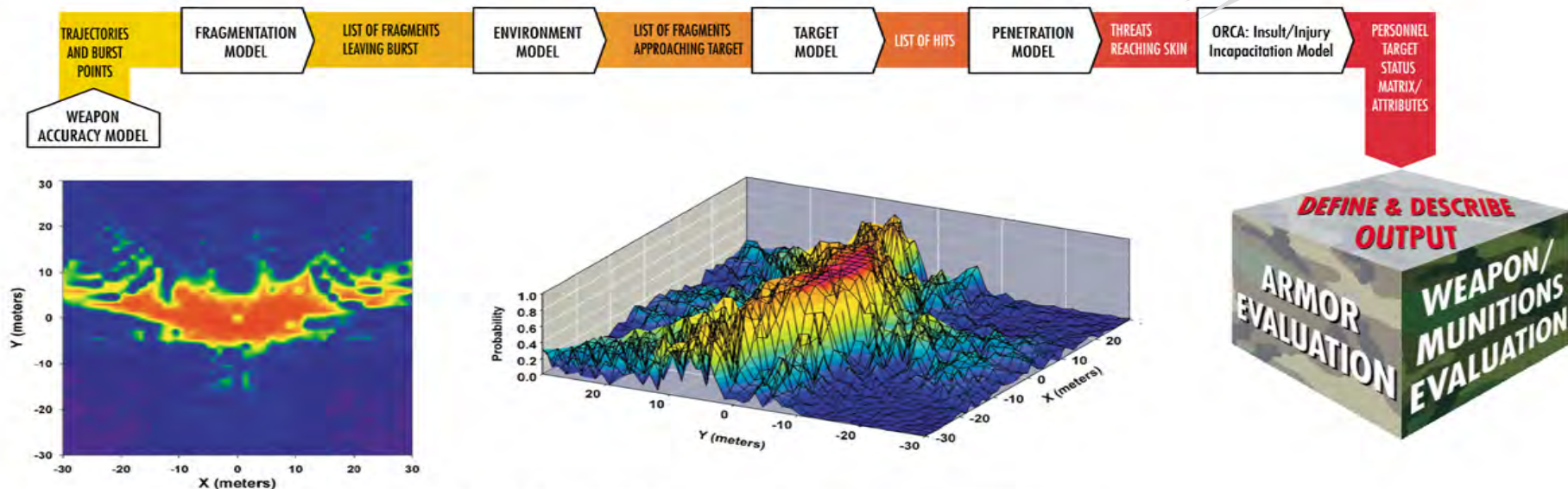
- Implemented Interface with Operational Requirement-based Casualty Assessment (ORCA) Library Functions
- Implemented Cunniff Equations For Ballistic Penetration
- Implemented Improved Representation of Munition Arena Test Data
- ICEM website, codes, and user's manual, available on-site, for authorized users



**ICEM Version 1.0 Scheduled for Release in Mar 02**

### Integrated Casualty Estimation Methodology

<http://www.sti.usa.com/icem>

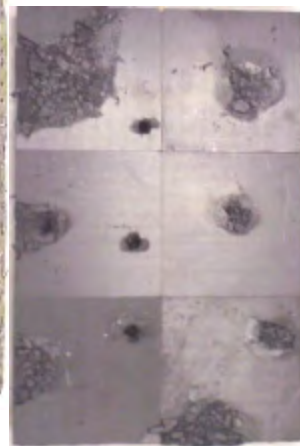
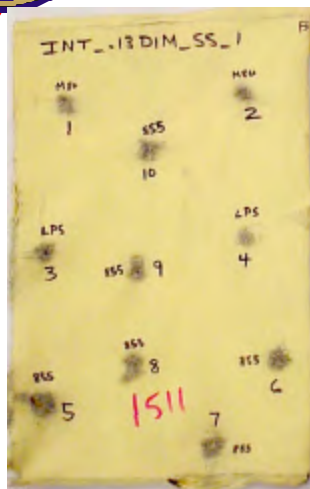


**Probability Of Incapacitation**

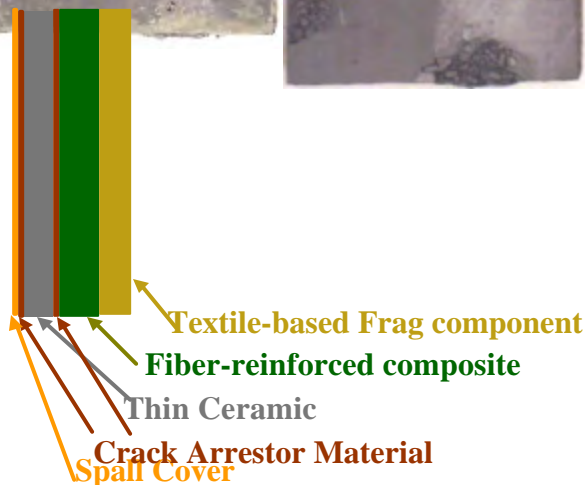




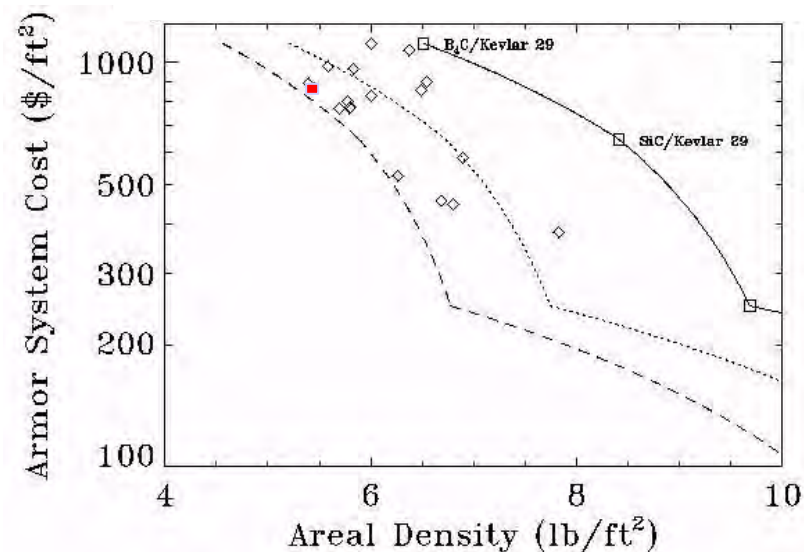
# Advanced Soldier Ballistic Protection



Ball Round



- Increasing state-of-the-art materials performance through improved composite architectures



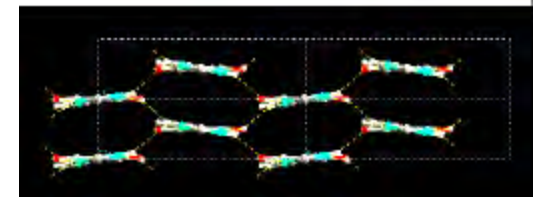
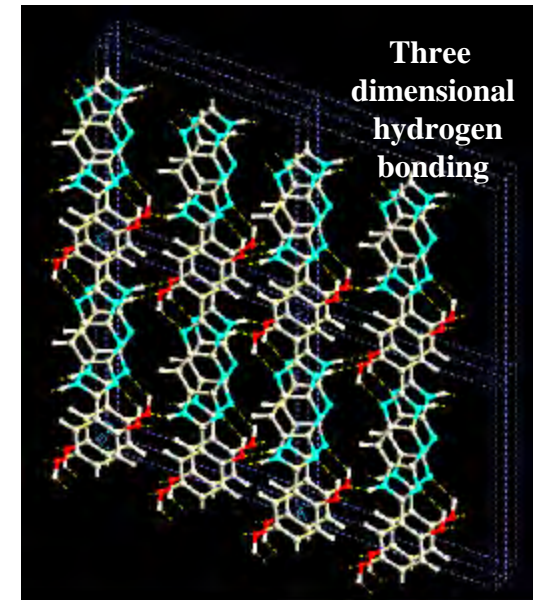
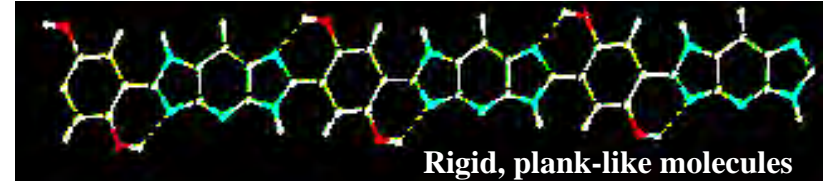


# Advanced Soldier Ballistic Protection



## M5 - New Fiber Technology

- M5 fiber is a new high performance experimental fiber.
- M5 has extraordinary potential for use in armor systems for personnel and vehicles, flame and thermal protection, as well as high performance textiles.
- Current production of the fiber is at the bench scale using a batch process.
- Fiber properties are less than optimal under current processing conditions.
- Research ongoing to bring material properties to full potential
- Current business plan has full scale production occurring in the US (North Carolina State University)



# Ballistic Protection for Improved Individual Survivability



University of Rhode Island



Walter Reed Army  
Institute of Research

**GENERAL DYNAMICS**  
Land Systems



**USAISR**  
U.S. Army Institute of Surgical Research

**dstl**

THE UNIVERSITY OF  
**TEXAS**  
AT AUSTIN



## Leveraging / Interactions

**Honeywell**



**twaron®**  
The Power of Aramid

**DUPONT** The miracles of science™

**M5** Magellan Systems International

**Simula**  
Government Products, Inc.



**NIJ**  
NATIONAL  
INSTITUTE  
OF JUSTICE

**Defence Research  
Establishment Valcartier**



Armed Forces Institute  
of Pathology

**Lawrence Livermore  
National Laboratory**

OAK RIDGE NATIONAL LABORATORY

UNIVERSITY of VIRGINIA

Simulation Technologies, Inc.  
**STI**  
MODELING AND SIMULATION FOR THE WARRIOR



WAYNE STATE  
UNIVERSITY

**CERCOM, INC.**

**ceradyne, inc.**



Southwest  
**Research**  
INSTITUTE



... a U.S. Department of Energy national security laboratory.



# BACKUP



# Advanced Soldier Ballistic Protection

## BEHIND ARMOR EFFECTS TECHNICAL PROGRESS :

- Established closer cooperative tie with Medical Research and Development community
- Established objective, dynamic biomechanical test method for accurately determining skull fracture potential of non-penetrating ballistic impacts on helmets. Validated through mechanical and cadaveric experimentation
- Established a risk of injury (fracture) curve for 9mm impacts on the helmet at various velocities, confirmed performance of current Army combat helmet (no skull fracture against non-penetrating 9mm)
- Substantiated low risk for neck injury due to non-penetrating high velocity 9 mm impact to helmet
- Transferred results of Army Head Injury Criteria to Army, Navy and USMC combat helmet developers.
- Conducted preliminary investigations of armor (vest/plates) on UK thoracic rig
- Established research methodology and instrumentation requirements for accomplishing an objective, dynamic, biomechanical test method for accurately determining blunt trauma limiting effects due to non-penetrating, high velocity, impacts on torso body armor



# Advanced Soldier Ballistic Protection

## MODELLING TECHNICAL PROGRESS

- Completed Beta version of Monte Carlo assessment of ballistic insults and estimation of casualties with new Integrated Casualty Estimation Methodology (ICEM) model,
- Established ICEM website, codes, and user's manual, available on-site, for authorized users
- Started preliminary validation and verification (V&V) for ICEM Version 1.0
- Designed and manufactured selected glass/plastic and plastic/plastic configurations at areal densities ranging from 2.5 lb/ft<sup>2</sup> - 5 lb/ft<sup>2</sup> to establish performance profile against various threats (frag/9mm handgun), testing in progress
- Continued characterization of high strain rate mechanical properties of textile fabrics for use in analytical and hydrocode models



# Advanced Soldier Ballistic Protection

## MATERIALS TECHNICAL PROGRESS

- Transferred technology for 1st generation small arms (ball) protection; established new baseline (5.2 lb/ft<sup>2</sup> ) for 2<sup>nd</sup> generation 25% reduction in weight
- Demonstrated technology for 35% reduction in countermine system
- Identified and evaluated new fibers with potential to meet out-year milestones
- Identified mechanism to enhance transparent armor through modification of ductile to brittle transition for polycarbonate/polymethyl methacrylate





# Advanced Soldier Ballistic Protection

## MATERIALS TECHNICAL PROGRESS

- Completed characterization of emerging bullet threat mechanical properties and failure characteristics, established baseline areal density (10 lb/ft<sup>2</sup> for M993)
- Identified material phase change in baseline boron carbide (B<sub>4</sub>C) ceramic against emerging threat which reduces performance of this ceramic, began investigation of alternate ceramics
- Conducted ballistic evaluations on early novel defeat concepts for emerging bullet threats providing insight in potential path forward
- Investigated the effect of processing pressure on mechanical properties and ballistic performance of ultrahigh molecular weight polyethylene composites with varying resin systems for 2nd generation ball protection, selected optimal candidate (s) for material integration evaluation with ceramics



# Advanced Soldier Ballistic Protection

## MATERIALS TECHNICAL PROGRESS

- Completed initial  $V_{50}$  evaluation of improved flat- panel laminated Zylon™ composite for fragmentation protection, demonstrated performance within 10% of FY03 objective. Environmental, flexural rigidity, transient deformation and ballistic performance of helmet shapes under evaluation
- Completed initial evaluation of improved flexible fabric armor systems. Demonstrated performance approaching goal performance. Results Classified. Environmental evaluations, cost reduction studies, and enhanced fabric architecture studies ongoing.
- Identified and started exploitation of new experimental high performance fiber, M5™ from Magellen Systems International. Fiber is being produced at bench scale with properties 1.5-2 times those of commercially available ballistic fibers. Potential for 3 times strength of Kevlar™. Working with company to bring to large scale production and commercial product. Current company plan is for production in the US

# Advanced Lightweight Grenade Launcher (ALGL)

## Program Overview



by: Dennis Lambrecht, ALGL Program Manager, NSWC Crane  
Jarl Eirik Straume, Nammo Program Manager  
Jeff Gramse, GDAS Program Manager



# ALGL Program Structure



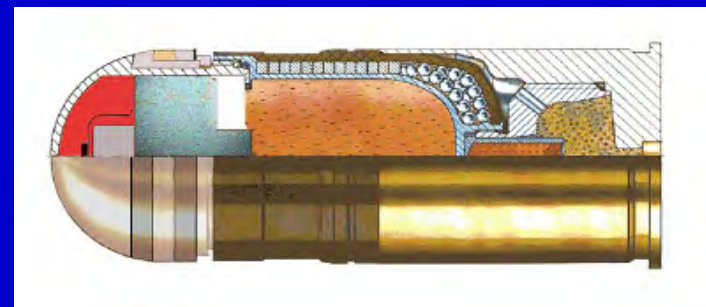
**GENERAL DYNAMICS**  
Armament Systems

**GENERAL DYNAMICS**  
Canada

**nammo**  
NORDIC AMMUNITION COMPANY



# ALGL System





# ALGL Program Objectives

- United States Special Operations Command:
  - Field an improved 40mm weapon system meeting Special Operations Forces (SOF) requirements
- Marine Corps Warfighting Laboratory:
  - Conduct a Concept Based Experimentation Program
- Foreign Comparative Test (FCT):
  - Type Classify / Type Qualify PPHE for USSOCOM



# USSOCOM Key Requirements



- Key Performance Requirements
  - Low System Weight
  - Maximum Effective Range
  - High Probability of Hit
  - Ground and Vehicle Mounted
  - Fire Control Provides Ballistic Solution
  - Enhanced Target Detection and Recognition
  - Uses Standard and Air-Burst Ammunition

# MCWL ALGL Experiments



## Mobility and Lethality:

- MK47 MOD 0 Machine Gun increased offensive capability
- ALGL fire control capability
- PPHE ammunition capability

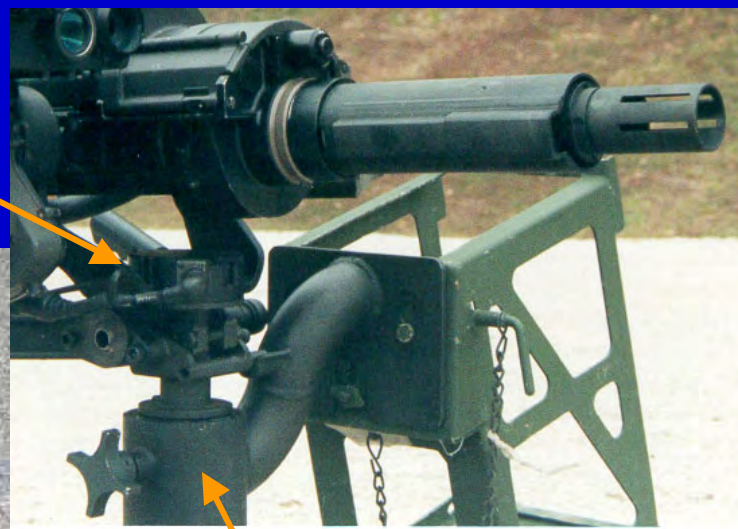


# ALGL System Components

MARK 47 MOD 0 Machine Gun

Fire Control

Mount

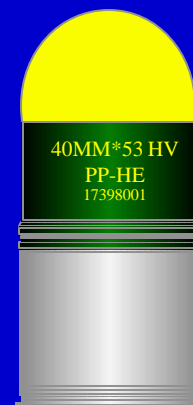


Vehicle Adapter

Ground Tripod

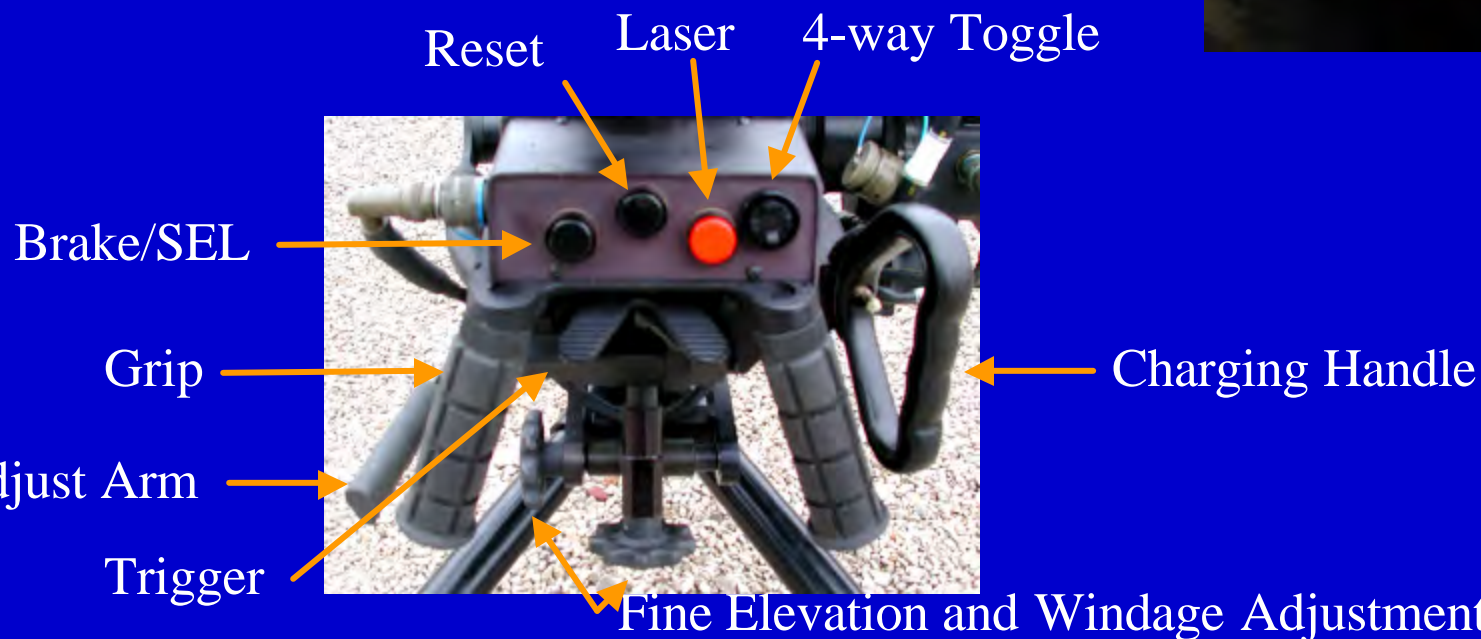
PPHE Air-burst  
Ammunition

Standard Ammunition



# MK47 MOD 0 Machine Gun

- Ergonomic Improvements
- Contacts in Chamber Set Air-burst Fuze
- Operator Controls





# ALGL Fire Control

- Lightweight Video Sight Fire Control

Display

Imaging / Ballistics

Brake/Super-  
Elevation



# ALGL Fire Control

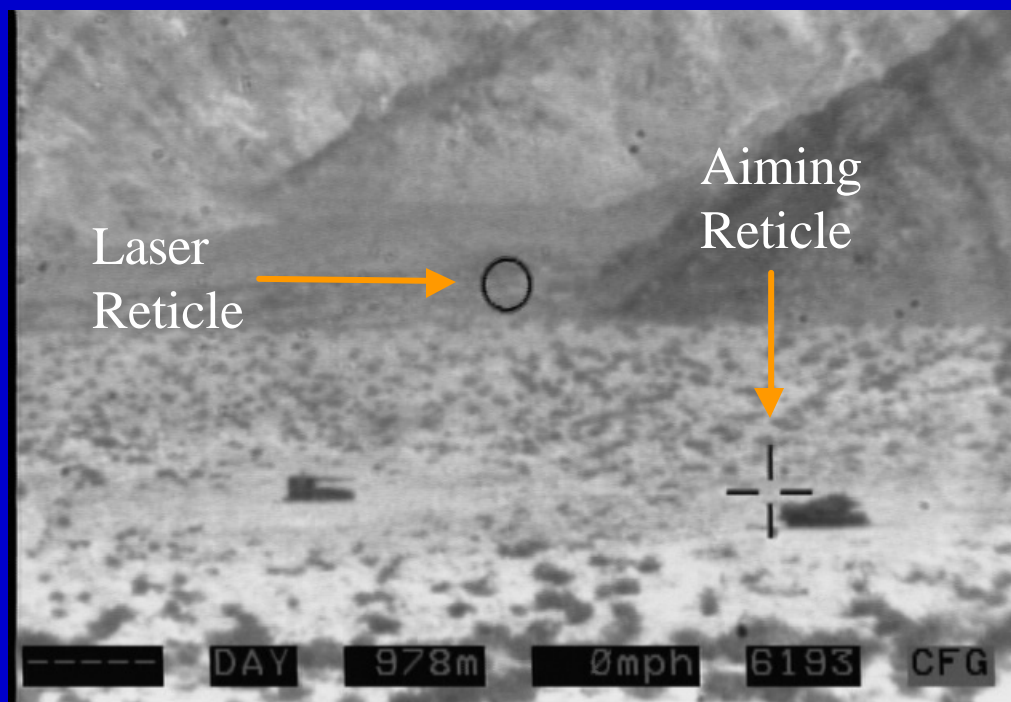
- Fire Control Imaging/Ballistics
  - Laser Range Finder
  - Video Image Processing
  - Night Vision
  - Ballistic Computer
  - Sets PPHE Air-burst Fuze
- Brake/Super-Elevation
  - Implement Ballistics Solution
  - Locks Weapon and Fire Control Together





# ALGL Fire Control

## Aiming Reticles for Laser and Weapon



Graphical User Interface  
operator adjustments, pre-designated targets, electronic range card

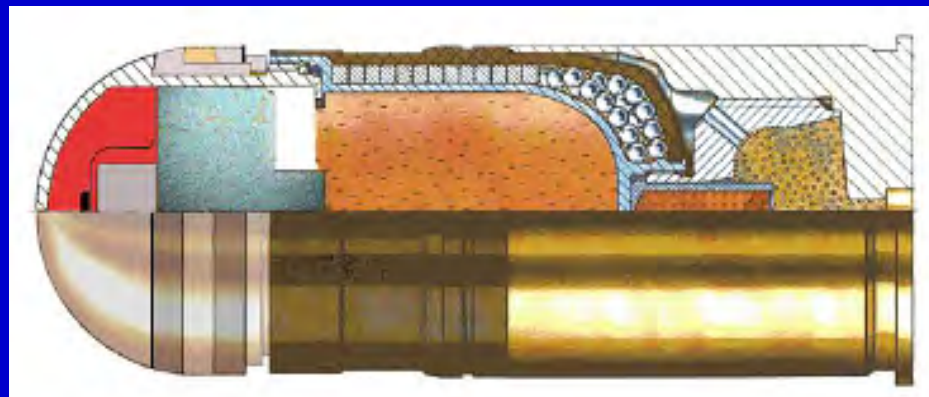
# ALGL Mountings

- Mount
  - interface for weapon, fire control
  - quick slew traverse and elevation
- Lightweight Ground Tripod
- Vehicle Adapter Kit

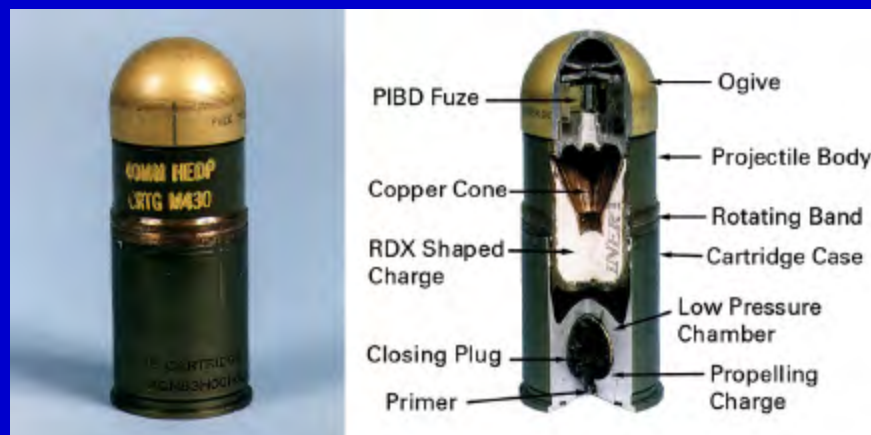


# ALGL Ammunition

- PPHE ammunition
  - air burst capability



- Standard 40mm ammunition
  - M430 HEDP
  - M383 HE
  - M918 TP
  - M385 TP





# ALGL System





# ALGL Schedule

	<u>System</u>	<u>Ammo</u>
<b>Milestone B</b>	<b>2Q / 01</b>	<b>1Q / 01</b>
<b>Developmental Testing</b>	<b>3Q / 02</b>	<b>1Q / 03</b>
<b>Operational Assessment</b>	<b>3Q / 02</b>	
<b>Safety Confirmation</b>	<b>4Q / 02</b>	<b>2Q / 03</b>
<b>System Prod. Certification</b>	<b>4Q / 02</b>	
<b>Milestone C / FRP</b>	<b>4Q / 02</b>	<b>4Q / 03</b>
<b>First Unit Equipped</b>	<b>2Q / 04</b>	<b>4Q / 04</b>

# Developmental Testing





# DT Summary

- Reliability
- Ballistics – firing tables and jump tests
- Platforms – hard stand, ground mount, earth box, vehicle
- Ammunition compatibility
- Adverse Environment
  - Hot, Cold, Icing
  - Salt fog
  - Mud – wet and dry
  - Sand/Dust – static and dynamic



# System Safety

- DTC Safety Release
  - Amendment 1, 19 November 2001
- Safety Confirmation
- WSESRB Introduction





# Operational Assessment

- OA
  - 3 ALGLs
  - NAG
  - ATC
  - May 2002





# NAMMO & GDAS Presentations



**GENERAL DYNAMICS**  
Armament Systems

**GENERAL DYNAMICS**  
Canada

**Nammo**  
NORDIC AMMUNITION COMPANY



# **FLAMELESS TRACER & MARKER**

## **2002 International Infantry & Small Arms Symposium**

**15 May 2002  
Atlantic City, NJ**

*Mark S. Leng, Stew Gilman, Leon Manole  
Close Combat Armament Center*



# AGENDA

- INTRODUCTION
- BACKGROUND
- TECHNOLOGY BENEFITS
- Modified M781 40mm TEST FIRINGS at TACOM-ARDEC
- QUESTIONS





# INTRODUCTION

- WHAT'S A TRACER ?
  - PYROTECHNIC MATERIAL (HEAVY METALS)
  - INITIATED UPON WEAPON FIRING
  - BRIGHT BURNING, TRAVELS WITH PROJECTILE
  - WEAPON CORRECTION
  - CAN START RANGE FIRES.....
- AMMUNITION FIRES
  - DANGEROUS
  - SMOKE IN SURROUNDING COMMUNITY
  - LOST TIME
  - COST TO EXTINGUISH



# BACKGROUND

- 1998 RESEARCH BEGAN UTILIZING VARIOUS ARDEC FUNDING SOURCES.
- PERFORMED PRELIMINARY TANK AMMUNITION TESTING.
- PATENT DISCLOSURE SUBMITTED.
- DEMONSTRATED M781 40mm GRENADE CAPABILITY.
- DEVELOPING TRACERS & MARKERS for MULTIPLE CALIBER AMMUNITION & VARIOUS MISSIONS.
- PROVIDING DEMONSTRATIONS to the USER COMMUNITY.



# TECHNOLOGY BENEFITS

- TRAINING BENEFITS
  - ELIMINATES TRACER FIRES.
  - ENVIRONMENTALLY FRIENDLY.
  - SIMULATES FLASH of EXPLOSIVE.
  - ALLOWS MODIFIED M781 to be USED AT NIGHT & DAY.
  - COST EFFECTIVE TO IMPLEMENT.
- TACTICAL BENEFITS
  - SIGNALING & IDENTIFICATION CAPABILITY.
  - INFRARED & VISIBLE LIGHT CAPABILITY.
  - ECONOMICAL



# 40mm M781 TEST FIRINGS

- DEMONSTRATED IR & VISIBLE TRACE MARK CAPABILITY with OVER 90 SUCCESSFUL FIRINGS in ARDEC ARMAMENT TECHNOLOGY FACILITY, OUTDOOR RANGE & FT BENNING.
- DEMONSTRATED TECHNOLOGY to PM, NATIONAL GUARD, INFANTRY SCHOOL, & OTHER USERS.
- SUCCESSFULLY ADVANCING PRESENT TECHNOLOGY to MEET USER NEEDS.



# FLAMELESS TRACER

## APPLIED to the 40mm M781 PRACTICE GRENADE



FIG 1. 40mm PROJECTILE WITH TRACER & MARKER CAPABILITY

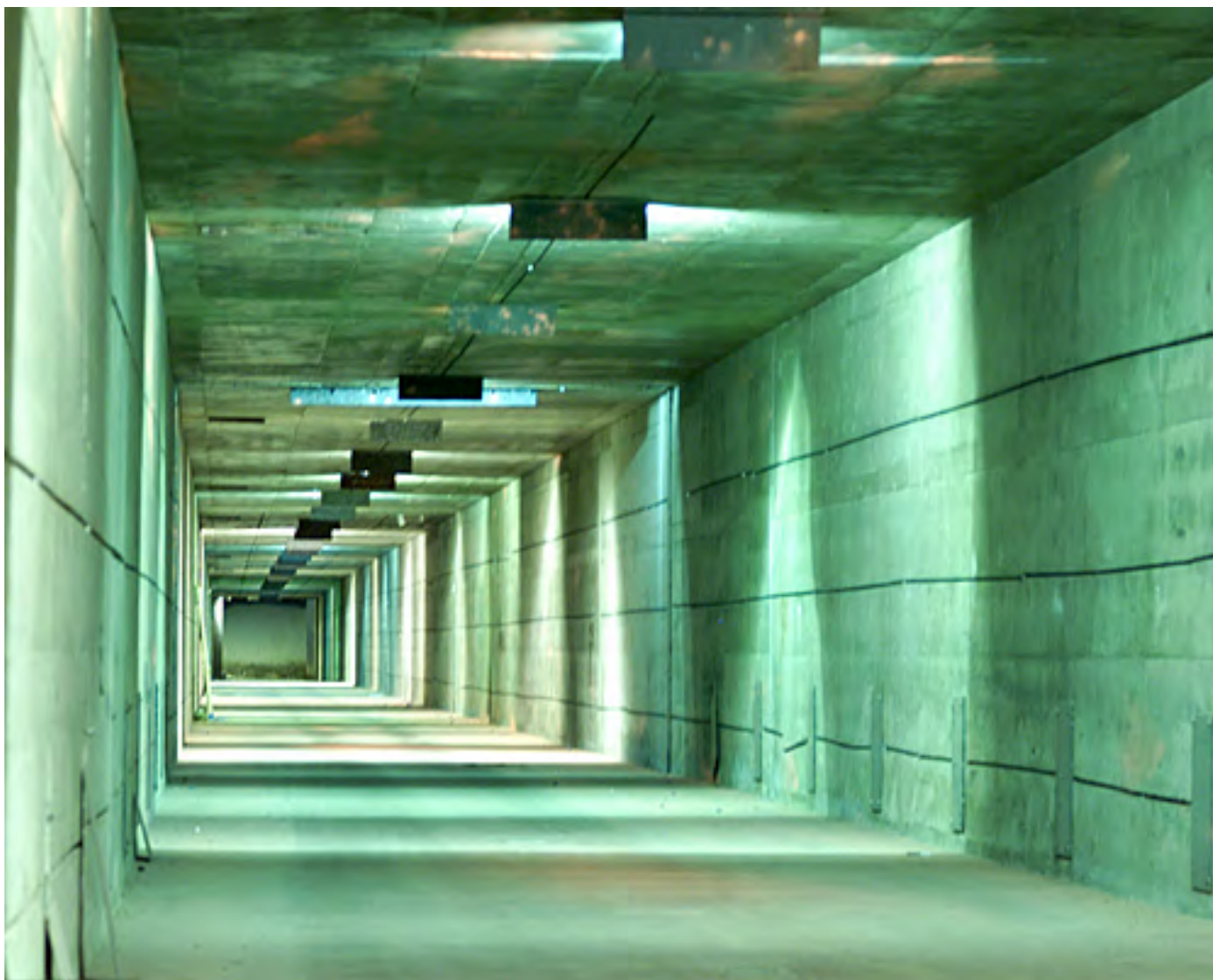


FIG 2. ATF- 300M RANGE NORMAL LIGHTING



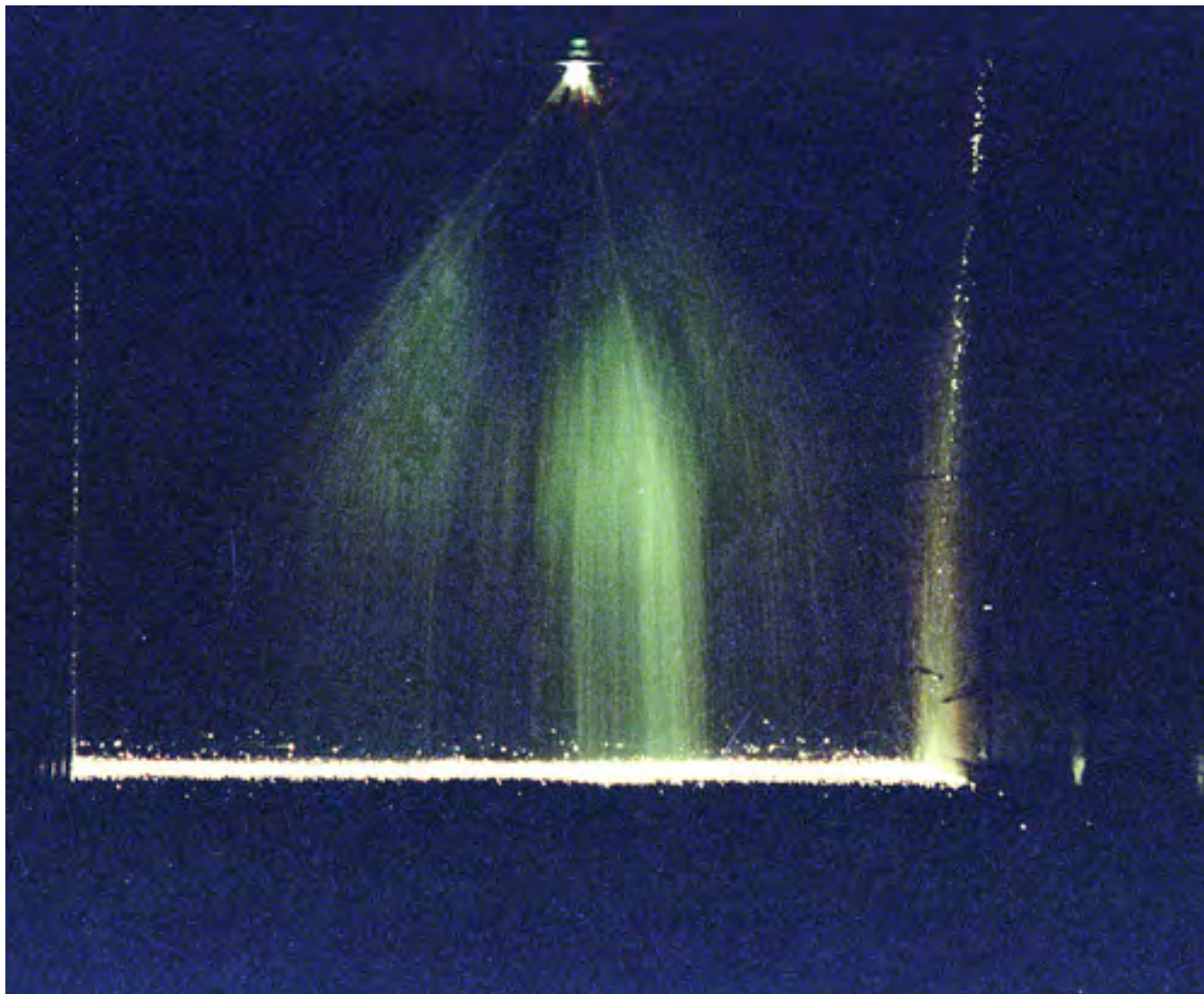


FIG 3. PROJECTILE IMPACTING CEILING

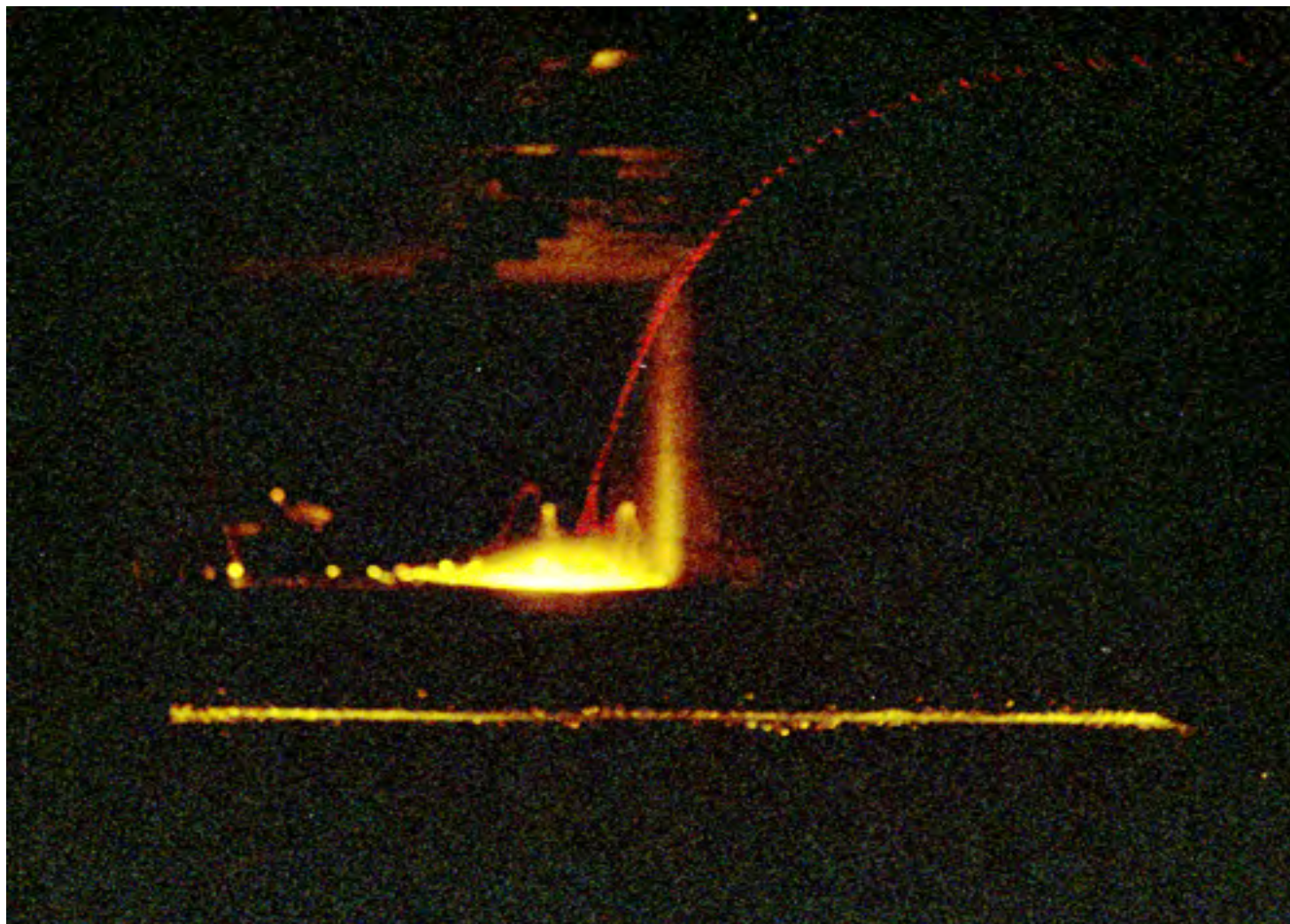


FIG. 4 40mm PROJECTILE with TRACE, IMPACTS FLOOR LEAVES MARK





FIG 5. MARKER (NO TRACER), INITIAL IMPACT on FLOOR RICOCHETING off the WALL and IMPACTING BACK to FLOOR



FIG 6. VIDEO OF 40mm TRACE & MARK in TACOM-ARDEC ATF



FIG 7. DAY TIME VIEW OF TARGET  
at PICATINNY OUTDOOR RANGE





FIG 8. ROUND MARKING TARGET at DUSK  
at PICATINNY OUTDOOR RANGE



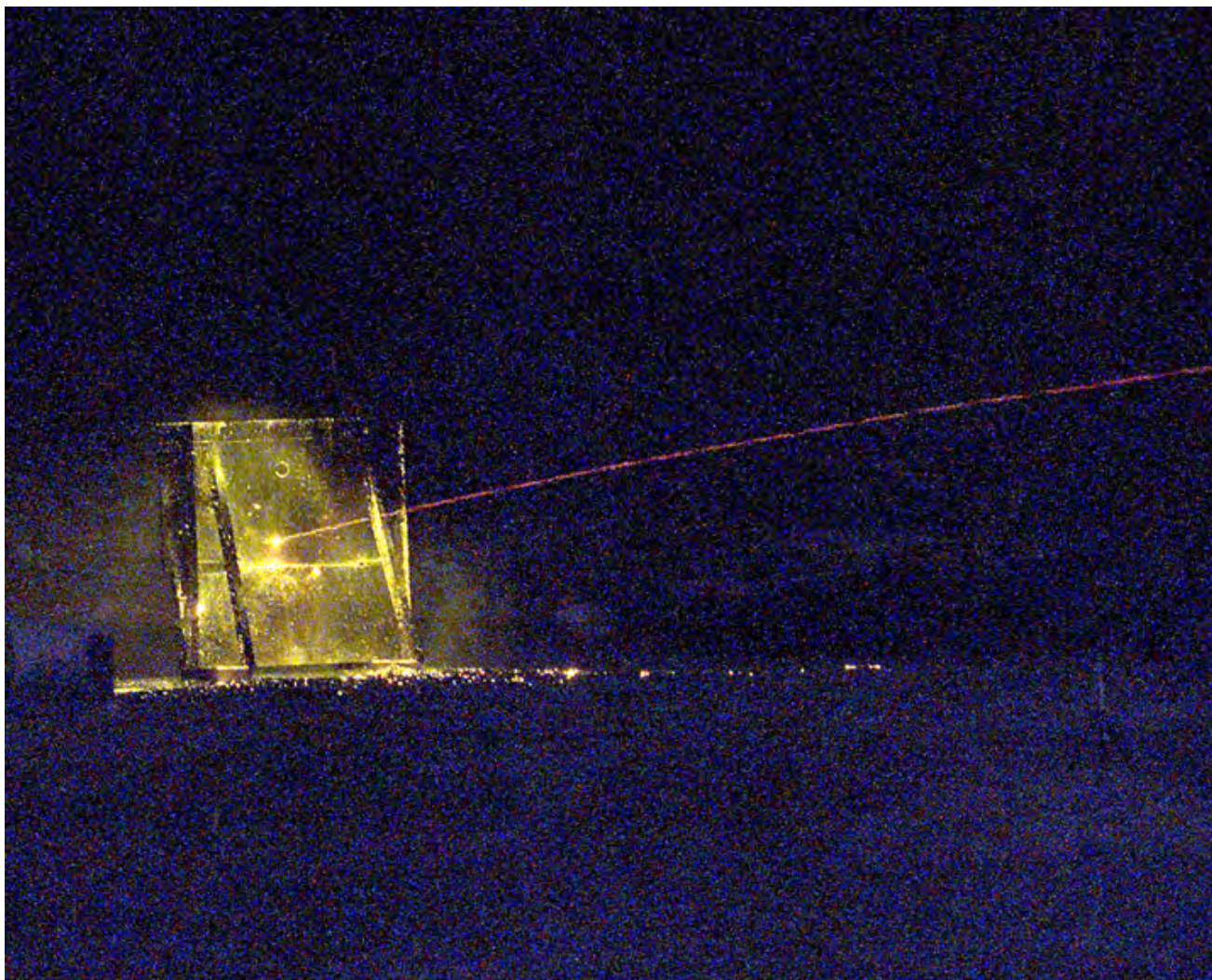


FIG 9. ROUND FIRED at NIGHT  
at PICATINNY OUTDOOR RANGE



FIG 10. VIDEO of FLAMELESS TRACE & MARK  
at PICATINNY OUTDOOR RANGE



# ARDEC Points of Contact

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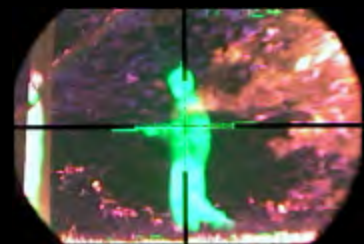
email: [لمانole@pica.army.mil](mailto:لمانole@pica.army.mil)

(973) 724-6516

# SNIPIR: HIGH PERFORMANCE COOLED THERMAL IMAGING WEAPON SIGHT

## NDIA Small Arms Symposium FLIR Systems, Inc.

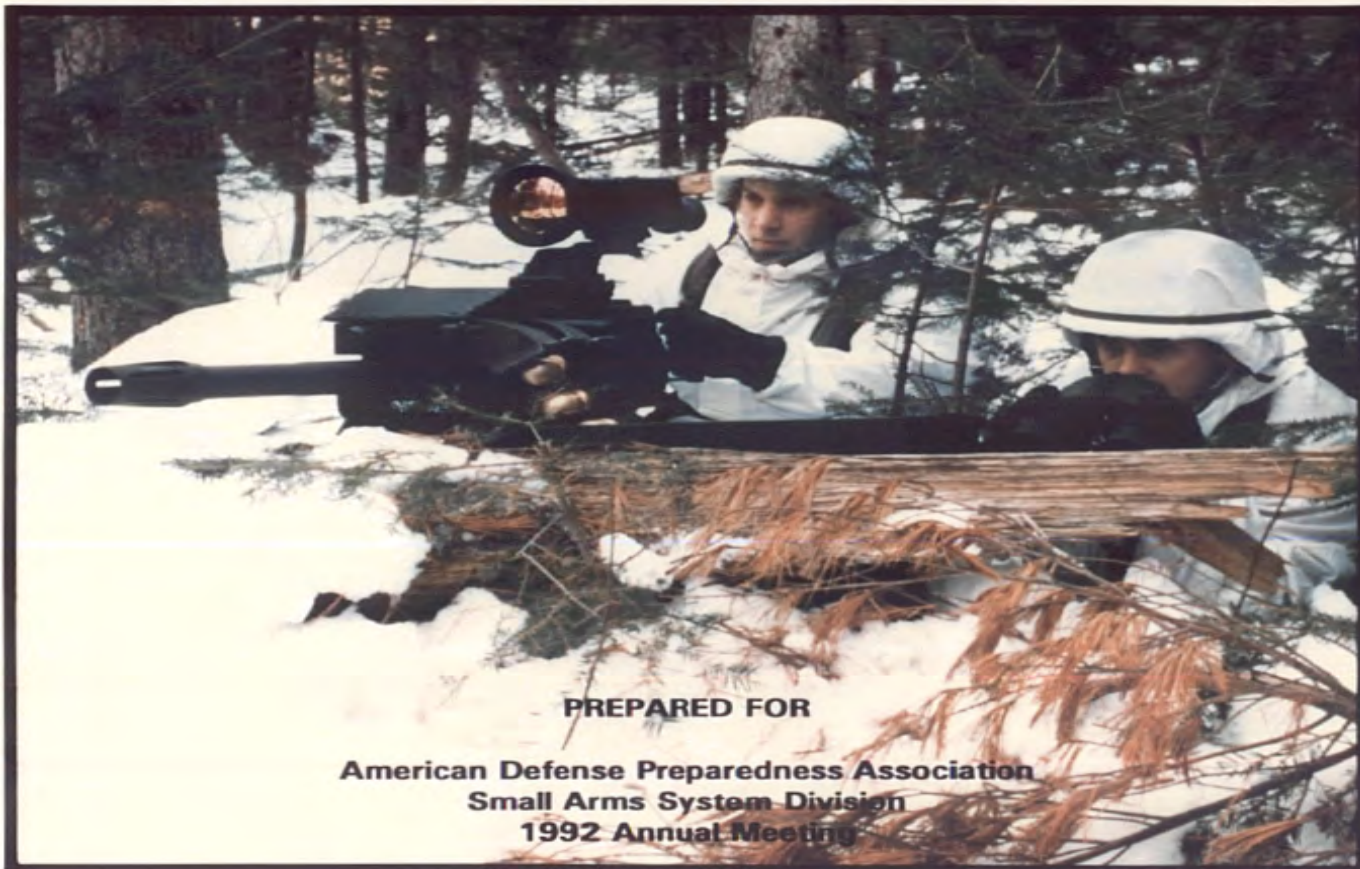
Presented By:  
JOHN G. LOOBY  
15 May 2002





# BEEN HERE BEFORE

## **MAG-600 MULTIPURPOSE THERMAL SIGHT**



**PREPARED FOR**

**American Defense Preparedness Association  
Small Arms System Division  
1992 Annual Meeting**

**By: John G. Looby  
Manager, Business Development, Advanced Programs  
Magnavox Electronic System Company  
Electro-Optical Systems Division  
46 Industrial Avenue, Mahwah, New Jersey 07430 (201)529-1700**

# PRESENTATION OUTLINE

- Company Overview
- User Needs
- Program History
- System Description
- Development
- Qual Test Results
- Production Status
- Future Growth



# BROAD SPECTRUM

## AIRBORNE



## GROUND



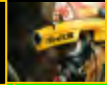
## MARITIME



## THERMOGRAPHY



## FIRE



# GROUND

FLIR has a solution for virtually every critical ground based application including force protection, surveillance, border patrol, perimeter security and special operations.



# SNIPIR

## NEED

- Long Range Targeting Visual Augmentation System That:  
**DOES NOT TOUCH MY SCOPE!**
- Clip-On Device



## TECHNOLOGY

- High Sensitivity IR Imager Folded Into a
- Visible Light Day Scope
- Resulting In **Image Fusion**
- Low Power Cooler/OTS Battery



## CDMQ

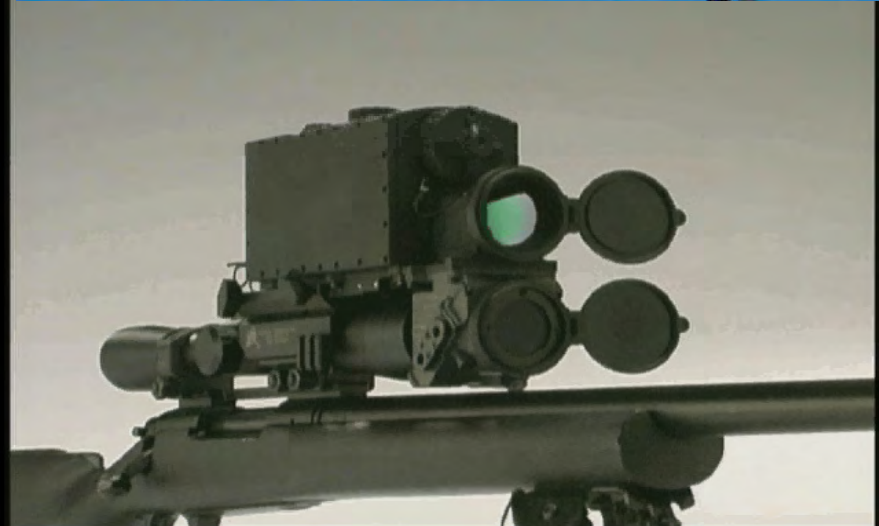


# PROGRAM HISTORY

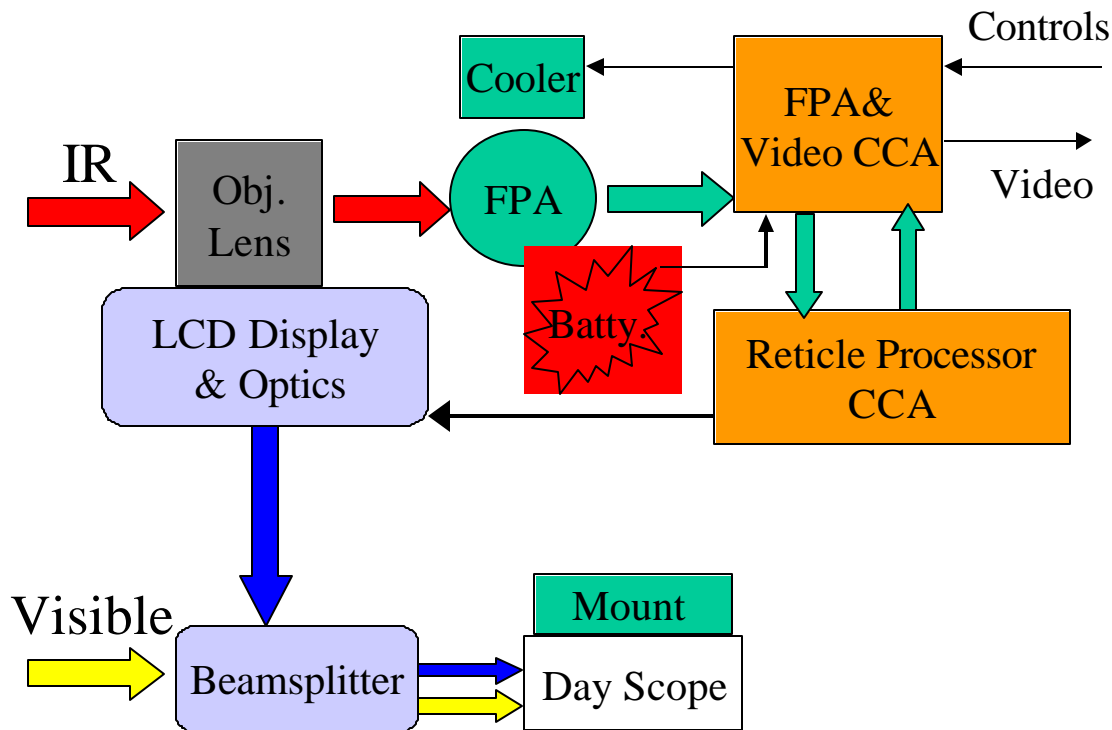
- Development Program Start: Oct "98"
- 3 Qual Units Shipped: Jan "00"
- Qual Tests: Mar "00"
- User Tests: thru Sept "00"
- Optic Upgrade: Oct "00"
- Re-Qual Optic: Nov "00"
- Production Award: May "01"
- Production Deliveries: Ongoing

# OPTICS EVOLUTION

- Original Requirement Called for Interchangeable Thermal Optics:  
75 & 150 mm Lenses
- 10X Leupold, Through Beamsplitter Provides Thermal Image Magnification
- Redesign Imbedded LCD Display in IR Telescope
- Redesign: **Reduced 1 lb. in System Weight, and 1.25" in System Height**
- Prior to Production



# SYSTEM DESCRIPTION



## Components:

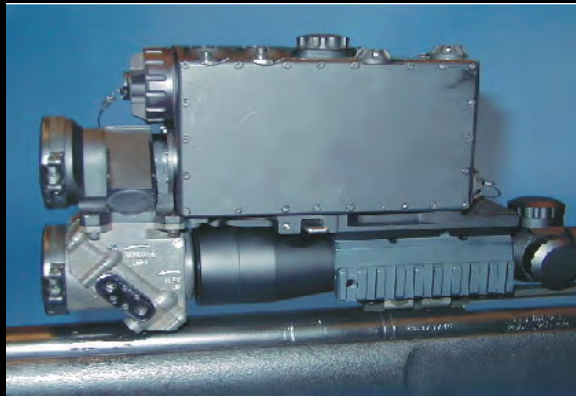
- TIPS Imager
- Objective Lens
- Beam Splitter
- Scope
- Mount



# SYSTEM SPECS

- RANGE: Recognize a Man > 1500 meters
- TECHNOLOGY: Cooled InSb Focal Plane
- OPTICS: 150 mm, f/4.0 (0.20 mr)
- DISPLAY: Green LCD, Through Scope / Beamsplitter
- WEIGHT: 4.5 lbs, Including Battery
- POWER: Single 3.6VDC Li "D"- Cell Battery
- Environmental: Sealed, Diveable to 66 Feet
- IMAGE: Visible or Thermal or FUSED!

# SNIPIR VIEWS



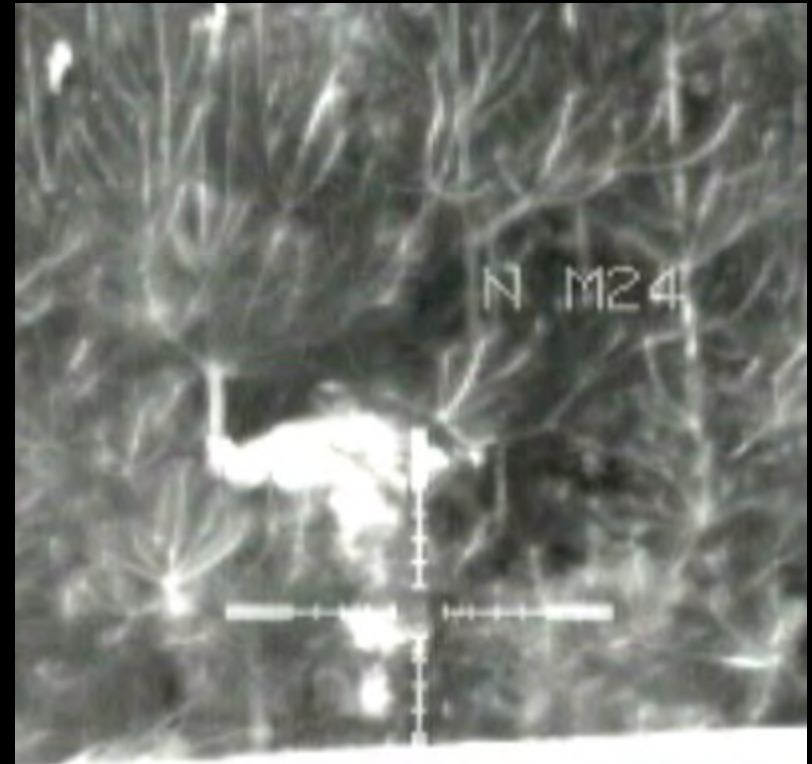
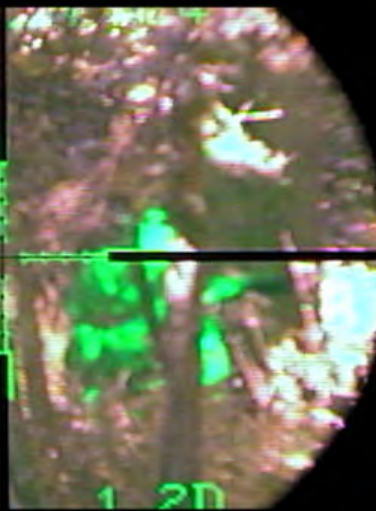
# SYSTEM VIDEO



# FUSION VIDEO



# USER VIEWS



# BORESIGHT PROCEDURE

- Zero In Day Scope (At a Desired Range)
  - Current Requirement 200 Meters
- Activate/Enable/ Turn on **SNIPIR**
  - Open Lens Cap
- Adjust Beam Splitter Mirror
  - Super Impose Visible and Thermal
- Re-Live Fire
  - Until Consistent Shot Groups



# QUAL TESTS RESULTS

- Imager Significantly Out Performed Spec.
- Live Fire Qual: 300 Rounds-.300 Win Mag
- Shoot Groups: <6 in @ 600 yds (<1.0 MOA)
- Three Qual Systems have Several Thousand Rounds Fired to date:  
(since Mar "00")  
**Without Failure!**

# PRODUCTION TEST



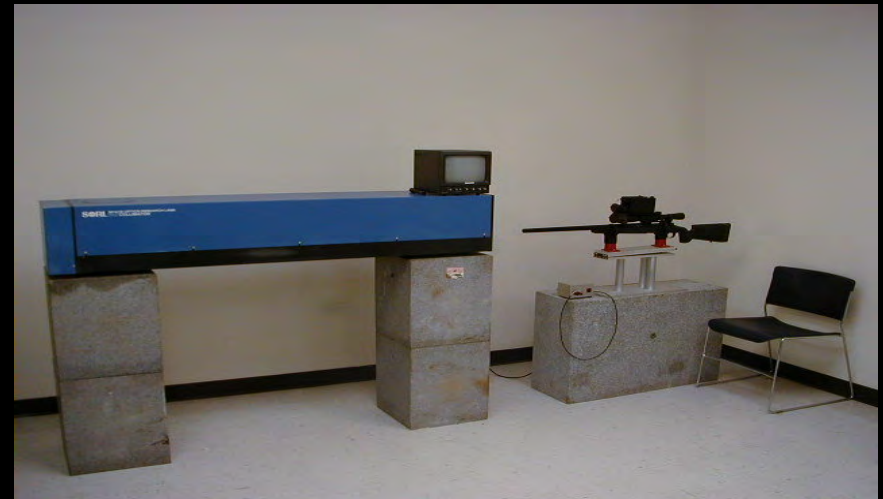
Monthly Production



Immersion Test



Bullet Trap



Collimator

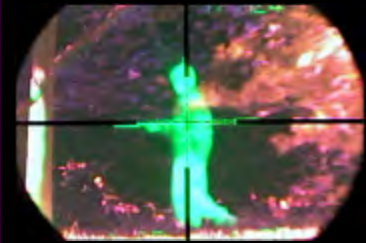
# ADDITIONAL APPLICATIONS

- **SNIPIR** Mods For Variable Scope
- **SNIPIR** Mods For Higher Power Scopes
- MIRV
  - Crew Served Weapons
  - STINGER Night Sight
  - MK 38 Deck Gun
- See Spot III
  - Forward Observer
  - Combat Air Controller



# SUMMARY

- **SNIPIR** Is Fully Qualified
- **SNIPIR** Is In Production
- **SNIPIR** Has Proven Consistent Performance
- **SNIPIR** Is The Visual Augmentation Clip-On System of Choice



# JUST A SHOT IN THE DARK



## SNIPIR